SEISMIC RISK PERCEPTION AND HOUSEHOLD ADJUSTMENT IN SALT LAKE CITY, UTAH

by

Eric Lee Martineau

A thesis submitted to the faculty of
The University of Utah
in partial fulfillment of the requirements for the degree of

Master of Science

Department of Geography

The University of Utah

May 2012

ProQuest LLC.
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106 - 1346

The University of Utah Graduate School

STATEMENT OF THESIS APPROVAL

The thesis of **Eric Lee Martineau**

has been approved by the following supervisory committee members:

Thomas J. Cova	, Chair	**03/07/2012** Date Approved
Kathleen Nicoll	, Member	**03/03/2012** Date Approved
Thomas M. Kontuly	, Member	Date Approved

and by **George F. Hepner** , Chair of the Department of **Geography**

and by Charles A. Wight, Dean of The Graduate School.

ABSTRACT

Millions of people in the United States are at significant risk of experiencing earthquakes. Understanding how households perceive seismic risk and prepare for an earthquake event is of increasing concern. This study examined the seismic risk perceptions and adoption of household seismic adjustments for residents of Salt Lake City, which is located along the Wasatch Fault System in the Intermountain seismic belt. Data were gathered using a mail-out survey sent to two different seismic zones: high ground shaking and high liquefaction. Analysis of the data, using independent samples t-test, examined relationships between 13 household seismic adjustments and respondents perceived risk, demographic characteristics, perceived protection responsibility, perceived personal safety responsibility, location of structure, and material and style of structure.

The results identify small but significant differences between the adoption of seismic adjustments and the two seismic zones. Respondents in the high ground shaking zone had adopted more seismic adjustments. It was found that those who had adopted certain seismic adjustments perceived themselves as more prepared, and households lacking in adoption of certain adjustments perceived outside groups as more responsible for protecting the public in earthquakes. In addition, female respondents reported a higher degree of perceived vulnerability. The vast majority of respondents perceived self-

responsibility as the biggest factor in earthquake preparedness but still looked to federal governments for assistance. These results suggest the concerns and adjustments that emergency personnel may focus on to better prepare, mitigate, allocate resources, and distribute information on the household level for earthquake hazards in Salt Lake City, Utah.

TABLE OF CONTENTS

ABSTRACT iii

LIST OF FIGURES vii

Chapter

1 INTRODUCTION 1

1.1 Background 2
1.2 Problem Statement 3
1.3 Research Questions 5

2 LITERATURE REVIEW 8

2.1 Risk Perception 8
2.2 Seismic Household Adjustment 10

3 METHODOLOGY 13

3.1 Study Area—Salt Lake City 13
3.2 Creation and Distribution of Survey Design 15
3.3 Analysis of Survey Data 17

4 RESULTS 18

4.1 Survey Respondents 18
4.2 Descriptive Statistics 22
4.3 Relationships 30

5 DISCUSSION 51

5.1 Adoption Rate of Seismic Responses 51
5.2 Responsibility for Earthquake Hazards 54
5.3 Vulnerability of Home 56
5.4 Preparedness and Seismic Zones 57
5.5 Weaknesses and Strengths 61

6 CONCLUSION.....63

APPENDIX: SURVEY OF EARTHQUAKE PREPAREDNESS ACTIONS.....65

REFERENCES 69

LIST OF FIGURES

Figure Page

3.1. Map of Salt Lake City's residential districts by seismic zone 14

4.1. Map of survey respondents in Salt Lake City 19

4.2. Characteristics of the survey participants 20

4.3. Percentage of adoption of 13 household seismic adjustments 23

4.4. Percentage of responsibility for different parties for protecting the survey participants from an earthquake event 26

4.5. Percentage that the survey participants expect their personal safety to be determined by the actions of various groups in an earthquake 29

4.6. Vulnerability of home to ground shaking 31

4.7. Vulnerability of home to liquefaction 32

4.8. Comparison of adoption of six household seismic adjustments by seismic zone....34

4.9. Comparison of seven household seismic adjustments by seismic zone 36

4.10. Comparison of household seismic adjustments by seismic zone.....39

4.11. Percentage of adopted household seismic adjustments 40

4.12. The number of adopted household seismic adjustments.....42

CHAPTER 1

INTRODUCTION

The process by which households reduce seismic vulnerability is called seismic hazard adjustment (Lindell & Perry, 2000). The seismic adjustments taken before an earthquake event include actions that mitigate, offer protection, extend relief, and aid in recovery. This process of seismic hazard adjustment is fundamental to improving seismic safety because it affects all levels of society. However, little is understood and known about this process, and it has become a barrier to further improvements in seismic safety (Lindell & Perry, 2000). Research has focused mostly on populations in California, Washington and the New Madrid Fault area, which includes areas in Illinois, Indiana, Missouri, Arkansas, Kentucky, Tennessee, and Mississippi. However, some of the research has generated conflicting results and incomplete data. Thus far, very limited research on risk perception and household seismic adjustment has been carried out in the Intermountain Seismic Belt region, which is a zone of earthquake activity that runs north-south from Montana, Wyoming, Idaho, and Utah in the north and southern Nevada/northern Arizona to the south. This thesis surveyed the perceived risk of residents in Salt Lake City, Utah and determined how this population has or has not

responded to risks related to earthquakes. The research also evaluated geographic and demographic factors in order to determine if patterns and significant relationships exist.

1.1 Background

The Wasatch Fault is one of the world's longest and most active normal faults, and it defines the eastern boundary between the Rocky Mountains and the Basin and Range physiographic provinces. This 240-mile-long normal fault extends from Malad City, Idaho in the north to Fayette, Utah in the south. The Wasatch Fault System (henceforth abbreviated WFS) is divided into 10 sections (or segments) that average about 25 miles each in length. The WFS is located within a greater regional area of active earthquake activity called the Intermountain Seismic Belt (Smith & Sbar, 1974). The geologic record indicates that the WFS produces surface ruptures during earthquake events with an estimated magnitude ranging from 6.5 to 7.5 on the Richter scale. Many of these large magnitude earthquakes have occurred in the distant past, with varying frequency for each segment (Utah Seismic Safety Commission, 2008).

The possibility of large magnitude earthquakes occurring along the Wasatch fault poses a severe risk to the surrounding population (Chang & Smith, 2002). Most of the 240-mile long stretch of the fault is heavily populated. Almost 80% of Utah's estimated 2.8 million people reside within about 15 miles of the fault, with the majority of the population along the Ogden-Salt Lake City-Provo corridor (Utah's Governor's Office of Planning and Budget, 2009). In addition, the majority of the state of Utah's transportation corridors and government facilities, along with the main airport also lie within 15 miles of the Wasatch fault. Also, 75% of Utah's economy surrounds the fault (Utah Seismic

Safety Commission, 2008). As a result, catastrophic consequences may occur to the surrounding area following an earthquake.

1.2 Problem Statement

The risk associated from seismic events has been an increasing focus of interest for government, policymakers and researchers since the 1971 San Fernando earthquake in California (Lindell and Perry, 2000). Many strategies have been implemented by state governments to reduce seismic risk and to mitigate damage and injury, including implementation of building codes, renovations, policies and public safety awareness practices (Utah Seismic Safety Commission, 2008). Despite these efforts, seismic risk and safety still remain major concerns. Limited knowledge about how people respond to seismic risk at the household level is a significant barrier in reducing risk from earthquakes and improving seismic safety. Many studies have been carried out to understand how households adopt seismic adjustments, but much is still not known about this process (Lindell & Perry, 2000). Most of the current research effort has focused on populations living along tectonic plate boundaries (e.g., California and Washington) and limited studies focusing on the major urban corridor along the intraplate tectonic setting of the WFS.

No catastrophic earthquake has occurred along the densely-populated Wasatch Fault zone during its modern settlement. However, since 1847, Utah has experienced at least 16 earthquakes with magnitudes ranging from 5.5 to 6.6 (Utah Seismic Safety Commission, 2008). The populous Ogden-Salt Lake City-Provo corridor's greatest historical earthquakes since 1847 include a magnitude 5.5 earthquake in Salt Lake City in

1910 and a magnitude 5.5 earthquake in Ogden in 1914. Therefore, most of Utah's residents have not experienced a moderately sized magnitude earthquake or a large magnitude earthquake. Such earthquake events along the WFS are comparatively infrequent as compared to the California San Andreas Fault System, for example.

The area along the WFS has been mapped into two discrete seismic risk zones based on earthquake models: a zone dominated by effects of ground shaking, and a zone experiencing liquefaction effects. Many areas of the Ogden-Salt Lake City-Provo corridor lie in the liquefaction zone, which has a substrate of weakly consolidated water-saturated lake sediment derived from ancient Lake Bonneville (Abbott, 2006). The modern remnant of Lake Bonneville is the much smaller Great Salt Lake, whose shores are also prone to liquefaction. During an earthquake, the houses, buildings, and roads located on top of uncompacted geologic substrates within the liquefaction zone may shake violently and collapse as the sediments de-water in the process of liquefaction. Liquefaction damages during seismic shaking can cause serious structural problems and building collapse that amounts to billions of dollars in damages.

In the 1970s the state of Utah began adopting seismic codes for buildings and infrastructure to mitigate the effects from earthquake events (Utah Seismic Safety Commission, 2008). Buildings erected prior to 1970 are at risk of being seismically unsafe. Many of the older houses and buildings in Salt Lake City are constructed of un-reinforced masonry and are particularly prone to collapse and other structural damage.

Salt Lake City is an ideal location for conducting a case study on risk perception and household seismic adjustments for several reasons. It is a large populous area along the Wasatch fault. The region has areas prone to liquefaction, and there are both old and

new houses. Furthermore, the region has not been extensively studied like earthquake prone areas in California. This thesis will add a new geographic perspective in order to better understand how households perceive seismic risk and adopt earthquake preparedness actions.

1.3 Research Questions

This research is centered on three questions associated with seismic risk perception and household adjustments:

1. How do variations in different seismic zones (i.e., site location of a given household near a fault or liquefaction areas) affect one's likelihood to perceive seismic risk and adopt household seismic adjustments?

Research about the adoption of household seismic adjustments indicates that geographic factors may play a role in how people prepare for and perceive risk to seismic hazards. Some studies demonstrate a possible relationship between location—namely, distance from a fault—and whether households might intentionally adopt seismic adjustments. Most people believe that the risk of a hazard decreases with distance from the hazard (Lindell & Hwang, 2008). Lindell and Prater (2000) compared the relationship between a city in California with high estimated seismic risk and a city in Washington with moderate estimated seismic risk and found that the associated populations differed greatly in hazard experience and risk perception, but differed only slightly in regard to adoption of household seismic adjustments. Studies that compare relationships between areas near a fault and areas in liquefaction zones can help to identify risk perception patterns between the two areas and relate any differences among household seismic

adjustments. More accurate and additional studies are needed in order to inform emergency managers about which factors lead to better adoption of earthquake preparedness actions by households, and to assess the steps that people have taken to reduce risk or prepare for an earthquake emergency.

The majority of the household seismic adjustment research has taken place in California (Lindell & Perry, 2000). Additional studies that focused on areas like the WFS in Utah may bring additional information on the adoption of household seismic adjustments in intraplate tectonic regions. This would allow emergency managers to adapt to any particular differences for seismically active intraplate areas and focus on specific geographic communities that are most at risk to seismic damage.

2. How do variations in population demographics relate with household perception of seismic risk and the adoption of household seismic adjustments in an intraplate seismic zone?

A review of 23 studies on seismic hazard adjustments in households by Lindell and Perry (2000) demonstrated that many different demographic variables significantly correlate with the implementation of seismic adjustments. According to Morrow (1999), vulnerability to a hazard is based on social and economic factors. Most of the seismic hazard response studies have focused on areas with frequent earthquakes such as California; however, it is not clear if the findings of previous studies are applicable to areas that experience infrequent earthquakes or in areas that have not had large magnitude earthquakes since colonization.

3. Does the type and age of a house affect that household's implementation of seismic adjustments?

Research indicates that hazard vulnerability is a combination of social and economic factors (Morrow, 1999). The construction type occupied by a household can play a significant factor in whether a person survives an earthquake. Brick houses are typically constructed with un-reinforced masonry, which can be particularly susceptible to earthquake damages. In addition, such characteristics as the age of the house (earthquake codes were not implemented in Salt Lake City until the 1970s) and the floor plan of the house (1 level, 2 level, etc.) may affect people's perception of earthquake risk and how they prepare. Most earthquake preparedness research focuses on specific household preparedness actions or on demographic variables. A study linking preparedness to the type of houses people live in, and how they perceive the likelihood of their households surviving a large magnitude earthquake would provide valuable information characterizing the preparedness level of the public. This would help emergency managers in planning mitigation strategies before an earthquake and towards implementing recovery efforts following an earthquake event.

CHAPTER 2

LITERATURE REVIEW

2.1 Risk Perception

The threat of natural disasters continues to increase for residents of the United States as its population keeps increasing each year. Much research has been carried out on trying to understand the natural disasters themselves, as well as how people perceive the risk associated with those disasters and the adoption of hazard adjustments. Despite this body of research, losses due to hazards have continued to increase over time (Mileti, 1999). Estimates for the average cost of natural and technological hazards in the United States are $50 billion (1999 USD) per year (Mileti, 1999). The high cost and consequences of disasters brings up concerns about ways in which people adjust to those disasters. The way in which households prepare for and cope with natural disaster is clearly not fully understood.

One area of focus in the published literature that explores the relationship of people and disasters is risk perception (Lindell & Hwang, 2008). Risk perception has been a topic of interest for researchers and policymakers for several decades (Sjoberg, 2000). Most Americans believe that they encounter more risk today than in the past, and that today's risks will be less than those occurring in the future (Slovic, 1987). An important area of concern for damage and casualties in the United States is earthquake

risk, which can be very severe (Abbott, 2006) and is a focus of attention for researchers (Lindell & Perry, 2000).

Many factors affect people's perception of personal risk to earthquake hazards. Lindell and Prater (2000) found that perceived personal risk is connected to the recency, frequency, and intensity of a person's personal interaction and experience with hazards. Perceived personal risk has also been correlated with various characteristics of households (Lindell & Hwang, 2008). Some household characteristics linked to risk perception include such the demographic attributes of ethnic minority status (Adeola, 2000), level of income and education (Fothergill & Peek, 2004), and the female gender (Fothergill, 1996). In addition, people tend to believe that the farther their distance from a hazard source, the less the risk they have in association with that hazard (Lindell and Hwang, 2008). However, with earthquake events this is not always the case. Earthquake waves travel at different frequencies, and certain kinds of waves may actually amplify in magnitude under different soil conditions and spatial distances (Abbott, 2006). Areas of weak sediment may exacerbate seismic shaking and/or liquefy, causing extensive damage to buildings, houses, and infrastructures (Utah Seismic Safety Commission, 2003).

In addition, the type of building materials used in one's house is a major factor in the personal risk associated with earthquakes. Steel buildings and wood framed houses are more flexible or ductile and these materials absorb the energy of earthquake waves better than materials such as masonry and concrete, which are considered rigid and tend to break during seismic events because they transfer the wave energy from the ground to the building itself (Utah Seismic Safety Commission, 2008). Buildings are shaken during an earthquake from the ground up, and the temporal duration of shaking is important. The

longer length of time a building is put under stress of shaking, the more likely it will be to deform or collapse (Utah Seismic Safety Commission, 2008).

Other important elements that deal with the capability of buildings to withstand earthquakes are its structural height and configuration. Square and rectangular buildings have been shown to deal better under earthquake stress than odd or irregular shaped buildings. In regards to height, shorter buildings tend to be shaken from side to side, while tall buildings sway back and forth and vertically as an earthquake releases its energy (Utah Seismic Safety Commission, 2008).

Accurately assessing building safety during an earthquake event is a complex function of construction type, style and configuration—in addition to elements of substrate strength and nature and duration of seismic shaking. Additional integrated research on this will inform people's perception of risk associated with earthquakes.

2.2 Seismic Household Adjustment

Individual households play a key role in reducing vulnerability to seismic hazards. However, many emergency managers believe that household residents expect government to take responsibility for earthquake risk and damage (Lindell & Whitney, 2000). Jackson (1977) found that respondents in California were less likely to believe that earthquake responsibility fell to households (10%) than to federal (54%), state (19%), or local governments (23%). Despite a belief individual households form the foundation for coping with earthquake hazards, the way in which individual households choose to deal with seismic vulnerability is not fully understood (Lindell & Hwang, 2008; Lindell & Prater, 2002).

Household seismic adjustments implemented before earthquake events include mitigation practices, emergency preparedness actions, and purchasing earthquake insurance (Lindell & Perry, 2000). Mitigation involves passive actions that protect against earthquakes at the moment of impact such as strapping water heaters to walls and bolting one's house to its foundation. Emergency preparedness is designed to help support response after the impact from a seismic event. This includes gathering such items as canned or dried food, bottled water and first aid kits. Earthquake insurance helps people financially recover from household damage following an earthquake (Lindell & Perry, 2000).

Researchers have sought to understand how seismic adjustments are adopted at the household level. Some findings reveal that hazard adjustments are likely to be adopted when they do not require a lot of knowledge, cost, skill, time and effort and cooperation with others and when they are effective in protecting persons and property (Lindell & Prater, 2002). Other studies have found that seismic adjustments are significantly correlated with past earthquake experience, while other researchers found limited or no correlations with regards to past earthquake experience (Lindell & Hwang, 2008). More research is needed to better understand this issue.

In addition, researchers have found correlations between people's adoption of household seismic adjustments and cost of the adjustment and household income (Fothergill & Peek, 2004). Most hazard mitigation practices are expensive and time consuming. This presents problems to those with little income or those who rent a property, or who intend to move from their households in the near future. In regards to hazard proximity, studies present conflicting evidence about whether or not households

adopt seismic adjustments as a function of their proximity to a fault (Lindell & Hwang, 2008). The conflicting evidence may be a result of the effects of perceived personal risk in that perceived risk causes hazard adjustment adoption. This thesis seeks to better understand the relationship between perceived personal risk and the adoption of household seismic adjustments. A case study in the Intermountain seismic belt along WFS in Salt Lake City has allowed for a new region to be explored.

CHAPTER 3

METHODOLOGY

This section will explain the study area of Salt Lake City and why it was chosen, as well as the reason that a survey was mailed out to residents of Salt Lake City in order to gather primary data to answer the research questions. It will also explain characteristics of the mail-out survey and its distribution. Finally, the methods used to analyze the data gathered from the survey will be discussed.

3.1 Study Area – Salt Lake City

The study area chosen for this case study is the Salt Lake City segment of the Wasatch Fault System (WFS) in the Intermountain Seismic Belt (see Figure 3.1). There are several reasons for the selection of this study area. First, the Wasatch fault is one of the world's longest and most active normal fault systems in the world (Utah Seismic Safety Commission, 2008). With almost 80% of Utah's population living within 15 miles of the Wasatch fault, the public faces a significant risk of seismic hazards. The study of the Salt Lake City segment of the WFS provides valuable preparedness and risk perception information to researchers of this world-class fault system and helps emergency managers to better understand the degree to which these households perceive

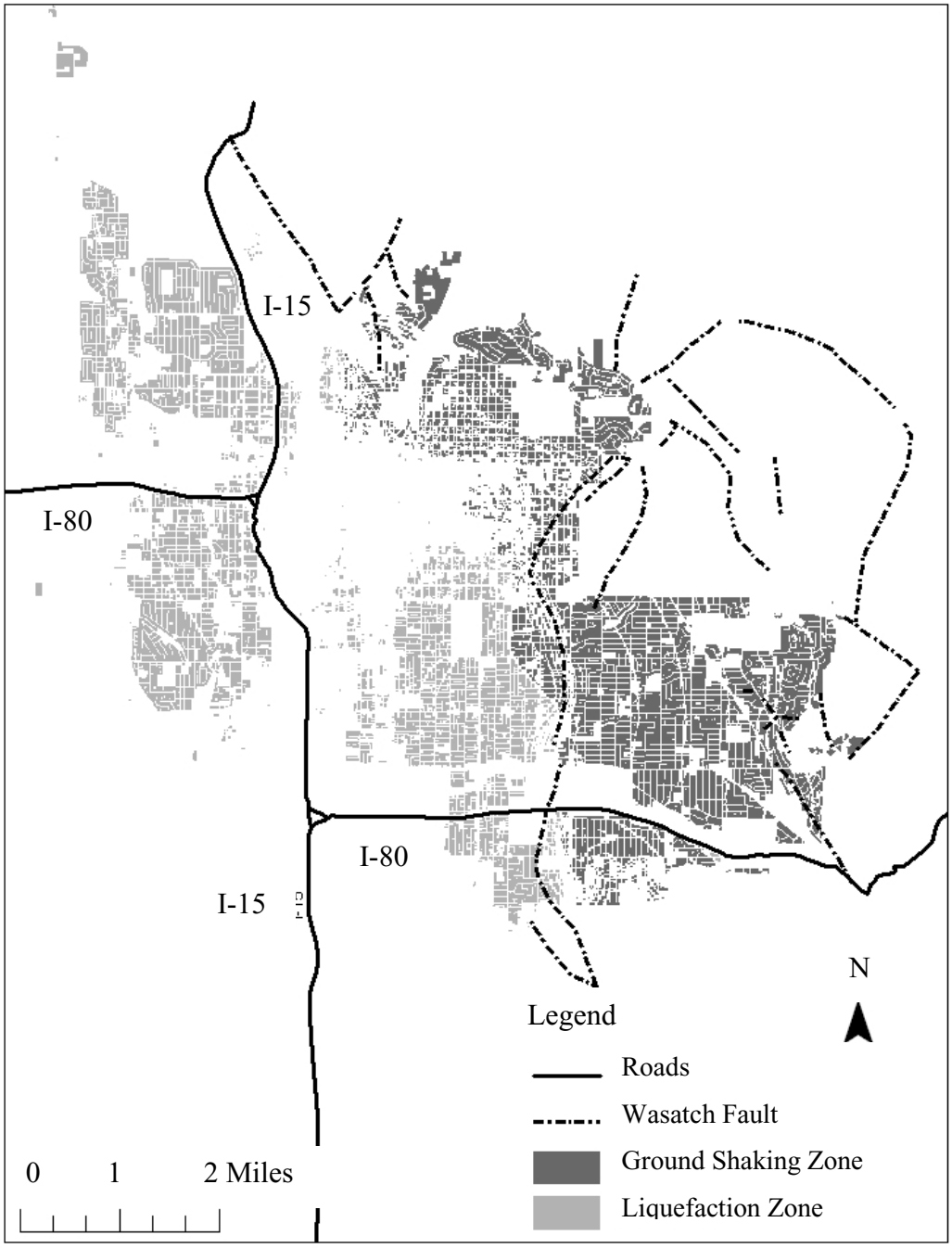

Figure 3.1 Map of Salt Lake City's residential districts by seismic zone.

risk, and what adjustments the households adopt to mitigate seismic hazards by geographic location. Additionally, a major review carried out by Lindell and Perry (2000) reviewed studies of household seismic hazard adjustments in which 20 of the 23 cases were carried out in California along the North American tectonic plate boundary. Only 3 of the case studies reviewed were done in intraplate regions, all of which were near along the New Madrid earthquake system. None of the reviewed studies were done in the Intermountain Seismic Belt region. Very few studies, if any at all, have focused on risk perception, preparedness or the adoption of household seismic hazard adjustments along the WFS. The WFS provides a rare opportunity to study an intraplate normal fault system that has received comparatively little attention in this field of research.

Finally, no significant large magnitude earthquake (>7.0 in magnitude on the Richter scale) has occurred along the Salt Lake Segment of the WFS since its modern settlement in 1847 (Utah Seismic Safety Commission, 2008). California experiences many frequent large magnitude earthquakes and the New Madrid fault has produced large magnitude earthquake since modern colonization (Abbott, 2006). This study is the first to assess risk perception and preparedness in a population living in an area that has not experienced a seismic event in the collective memory. The Wasatch Front lacks frequent large magnitude (>7.0) earthquakes yet its population is at severe seismic risk, with a high vulnerability.

3.2 Creation and Distribution of Survey Design

The method of data collection chosen for this thesis is a mail-out survey. The mail-out survey was sent randomly to residents of Salt Lake City, Utah in order to gather

primary data about the preparedness and risk perception in households situated in the region. The mail-out survey technique has been successfully employed by other studies carried out in this field of research to gather primary data at the household level (Lindell & Perry, 2000; Lindell & Prater, 2002). This case study of the Salt Lake segment of the Wasatch fault measured the preparedness actions or adoption of household seismic hazard adjustments of residents living within the Intermountain Seismic Zone, and the seismic risk perception of individual households.

A survey on earthquake preparedness actions created by Michael Lindell of the Hazard Reduction and Recovery Center at Texas A&M University is the model for this survey. The mail-out survey was sent to Salt Lake City area residents, which includes households near the WFS and households in liquefaction zones. The number of surveys mailed out was 1000. The surveys were mailed out from a random selection of addresses taken from Salt Lake City and its surrounding communities using a stratified sampling method.

The target population of the survey includes individuals 18 and older, all ethnicities, education levels, genders, and social statuses. It also targeted a variety of household construction types. The agreement to participate in the survey was not mandatory, but based on the participant's voluntary choice to complete and return the survey. The individual that is randomly chosen to participate in the survey was able to freely disregard the survey at will. The survey included close-ended questions regarding earthquake preparedness, risk perception and household seismic adjustments using a Likert scale as based on Lindell's survey. In addition, questions asked about the demographic variables of the households. The survey was two pages in length and took

about 10 minutes to complete. The participant mailed back the survey using the provided self-addressed and stamped envelope.

Geocoding was employed on the mail-out surveys. This was done for three reasons. First, geocoding helped ensure that the participant's information is kept private and in compliance with IRB requirements for a mail-out survey. Second, the technique of geocoding allowed data entry into a GIS format for mapping the survey results. Finally, geocoding helped to identify the location of those respondents who had returned the survey.

3.3 Analysis of Survey Data

Simple descriptive statistical methods were conducted on the data gathered from the surveys. Analysis of people's responses was carried out to resolve patterns and identify significant relationships that may exist. Independent samples t-test and correlation methods were implemented to test the joint effects of two or more variables regarding risk perception, seismic adjustments, household demographics (Lindell & Perry, 2000). Some of these variables include ground shaking potential, distance to fault, liquefaction potential, building type and demographic characteristics. Simple proportional statistics were also carried out to characterize the population and to determine for example the percentages of respondents living in the liquefaction zones as compared to areas closest to the WFS.

CHAPTER 4

RESULTS

This chapter compiles the results from the seismic risk perception and household response survey that was sent to Salt Lake City residents. A description of the various characteristics of the population that responded to the earthquake preparedness survey, the actual household seismic adjustments respondents have taken against earthquakes, their perceptions about who is responsible for protecting them from an earthquake hazard, and their beliefs regarding what extent actions taken by certain groups determine their personal safety from an earthquake is presented. Finally, several significant statistics are analyzed that pertain to risk perception and the actions people take to prepare for an earthquake.

4.1 Survey Respondents

Of the 1000 seismic risk perception and household response surveys sent out to residents of Salt Lake City, 198 surveys were returned. Therefore the response rate for this survey is approximately 20%. Figure 4.1 shows the survey study area of Salt Lake City, along with the Wasatch fault, high ground shaking zones, high liquefaction zones, and the location of all 198 survey respondents.

Figure 4.2 summarizes the various characteristics of the respondents to the

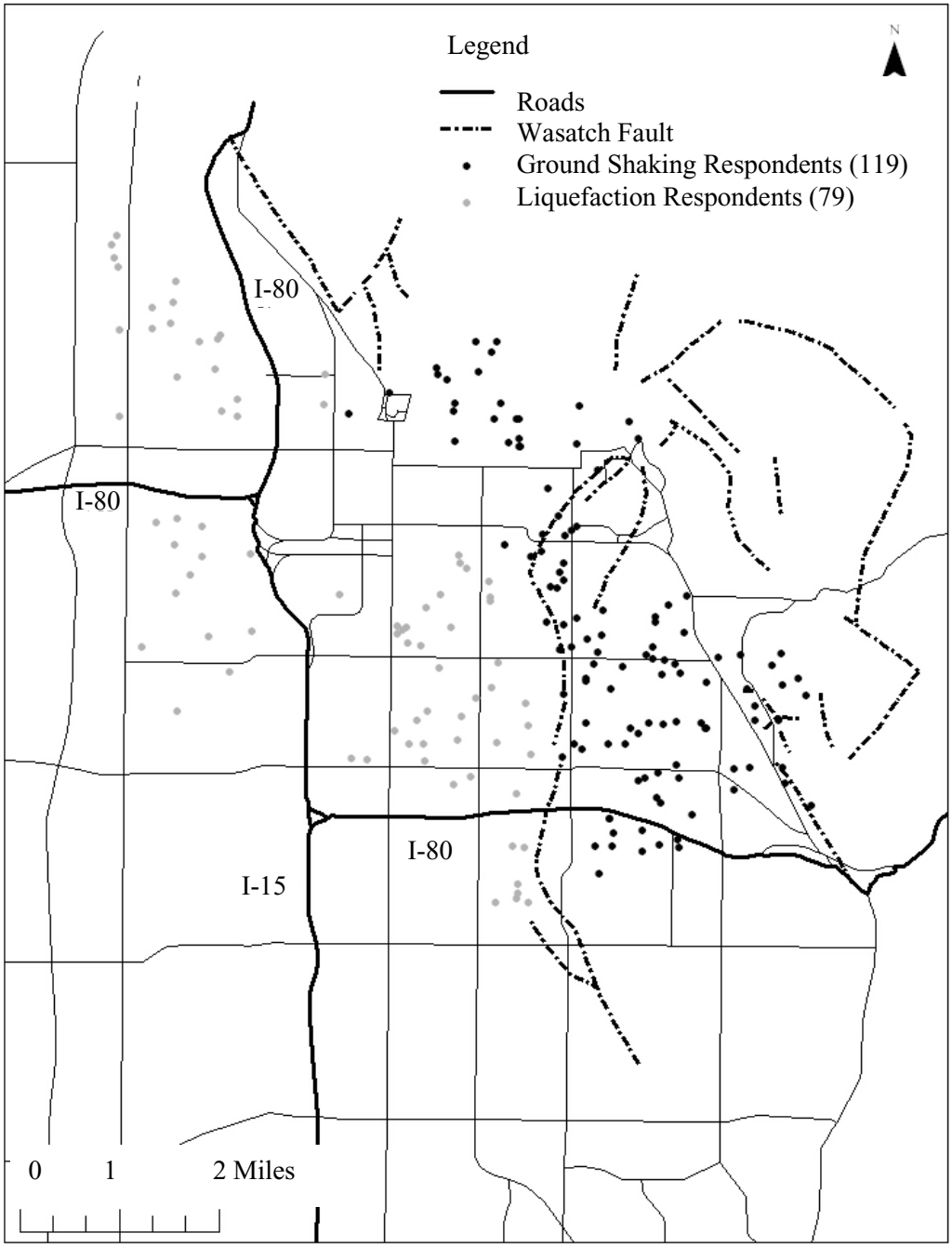

Figure 4.1 Map of survey respondents in Salt Lake City.

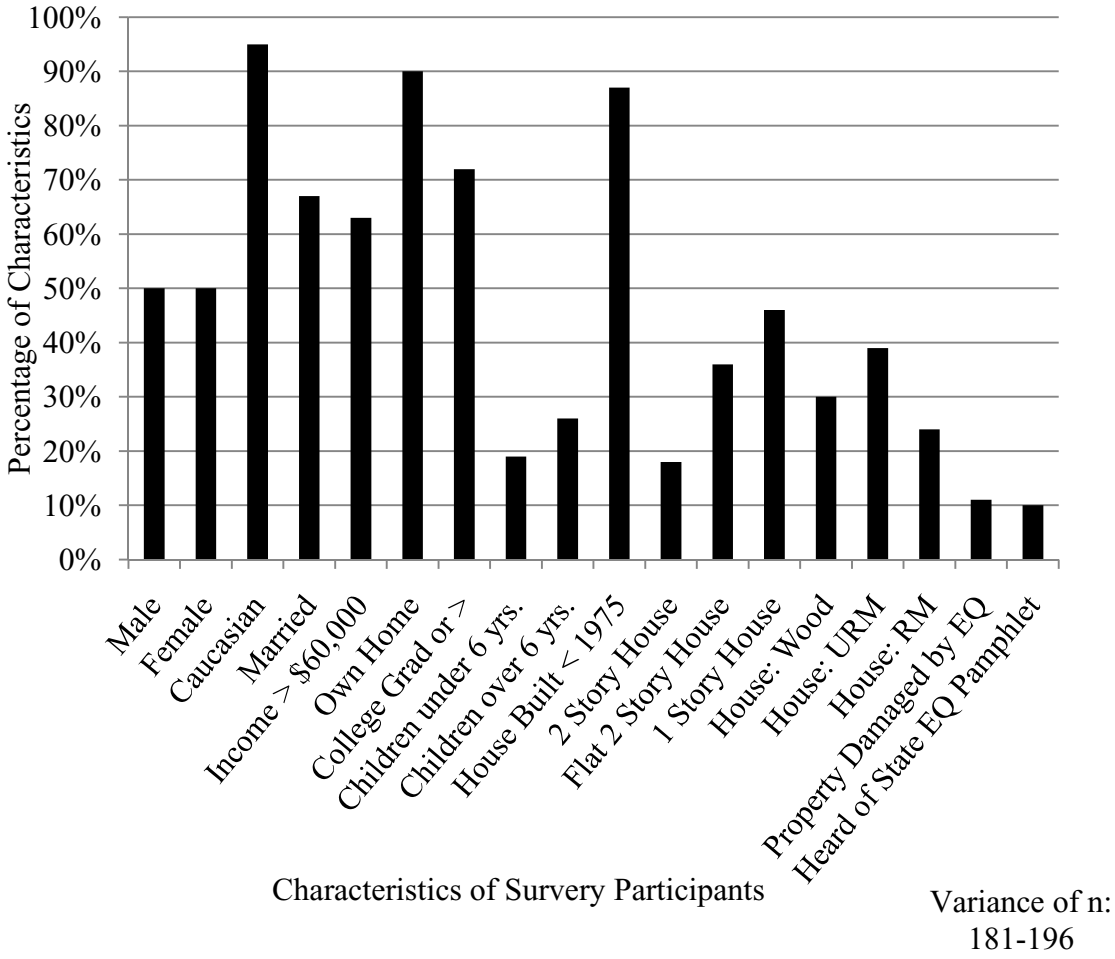

Figure 4.2 Characteristics of the survey participants.

household earthquake preparedness actions survey. All the survey respondents came from locations in Salt Lake City. The ratio of male to female respondents is an even 50%. The vast majority of the survey participants (95%) were Caucasian. Over 65% of the responding households are married, 19% have children under 6 years old, and 25% have children over 6 years old. Over half of the respondents earn in excess of $60,000 per year in income. The survey respondents were well educated, with over 70% of the population classifying themselves as college graduates or with additional graduate or professional education. The vast majority of survey participants own the home that they reside in, and 87% of their homes were built before 1975, which is around the time when earthquake codes began to be implemented for houses in the state of Utah.

Of the three types of houses mentioned in the survey, 18% were two or more stories with stepped floors, split levels, or large openings in floors, 36% had two or more stories with flat floors, no steps in the floor and no large openings in floors, and 46% were one story ramblers. A good proportion of house types is represented among the respondents; unreinforced masonry being the highest at 39%, followed by wood houses at 30% and reinforced masonry houses represented in only 24% of the responding population.

Finally, only 10% of respondents have heard of an earthquake awareness and information pamphlet issued in 2009 by the Utah Seismic Safety Commission (Utah Department of Public Safety, 2011). This pamphlet, entitled “Putting Down Roots in Earthquake County” is free and widely available at state offices and online. It was heavily advertised as a comprehensive resource that provides information about the threat posed by earthquakes in Utah, particularly

along the Wasatch Front, and explains how residents can prepare for, survive, and recover from a seismic event.

In summary, the majority of survey respondents are Caucasian, married, have college degrees, earn a yearly income greater than $60,000, own their own home, and their homes were built before 1975.

4.2 Descriptive Statistics

4.2.1 Household Seismic Adjustments

This section describes the adjustments that the survey respondents indicate they have taken in order to prepare themselves from a major earthquake affecting their home. This study assessed 13 household seismic adjustments that included costly adjustments like purchasing earthquake insurance and time-consuming earthquake activities like joining an emergency community organization. In other words, some of the household seismic adjustments involve having things while others involve doing things. Some of the adjustments involve just knowing about information related to earthquake preparedness. Figure 4.3 shows the percentage of household seismic adjustments taken by the survey respondents.

Owning wrenches is the number one household seismic adjustment that the survey respondents have adopted. Wrenches enable residents to shut off their utilities in case of an earthquake. Ninety-four percent of the survey participants owned wrenches, which is 14% higher than the next highest household seismic adjustment. The next highest adjustment is associated with ownership of wrenches and assesses whether or not one has learned how to shut off one's utilities; the affirmative response at 80%.

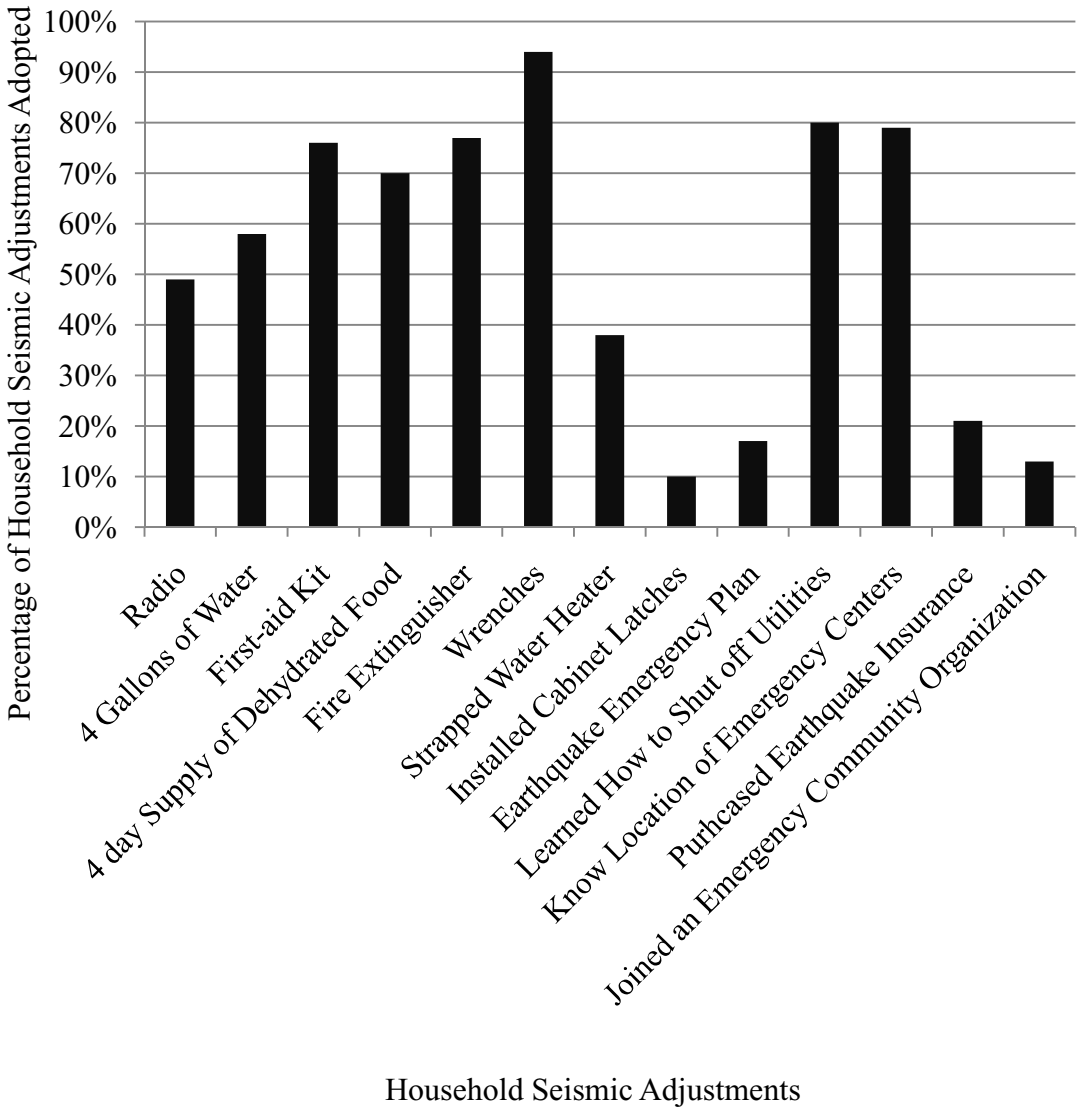

Figure 4.3 Percentage of adoption of 13 household seismic adjustments.

Following closely behind at 79% is knowledge of the location of nearby medical emergency centers. Having a fire extinguisher in the participant's place of residence had a 77% adoption rate, while having a complete first-aid kit came in with a response of 76%.

Those respondents who had at least a 4-day supply of dehydrated food equaled an even 70%, while those who had stored at least 4 gallons of water in plastic containers numbered only 58%. Only 49% of the respondents own a working radio. Even fewer respondents have strapped down their water heater, with 30% of the participants following this safety measure for earthquake preparedness. Fewer people indicated that they purchased costly household earthquake insurance, with a response of 21%. Only 17% of the respondents developed a household earthquake plan, and 13% indicated that they joined an emergency community organization. The least adopted household seismic adjustment was installing cabinet latches to keep them securely closed, an activity that only 10% of the survey respondents accomplished. See Table 4.1 for a list of the household seismic adjustments in order of the most adopted to least adopted practices.

4.2.2 Responsibility for Protection

This section describes the extent to which the respondents of the survey think certain groups are responsible for protecting them from an earthquake hazard. Figure 4.4 represents the survey responses organized as various columns of several groups or responsible parties that give protection against earthquakes. Each column is divided up by the responses from a Likert scale with 1 being "not at all" and 5 being "very great extent." In addition, each column is shown with just the responses on the Likert scale

Table 4.1 Percentage of adopted household seismic adjustments.

Seismic Adjustments	Percent Adopted
Wrenches	94%
Shut Off Utilities	80%
Emergency Centers	79%
Fire Extinguisher	77%
First-aid Kit	76%
Food	70%
Water	58%
Radio	49%
Water Heater	38%
Earthquake Insurance	21%
Earthquake Plan	17%
Community Organization	13%
Cabinet Latches	10%

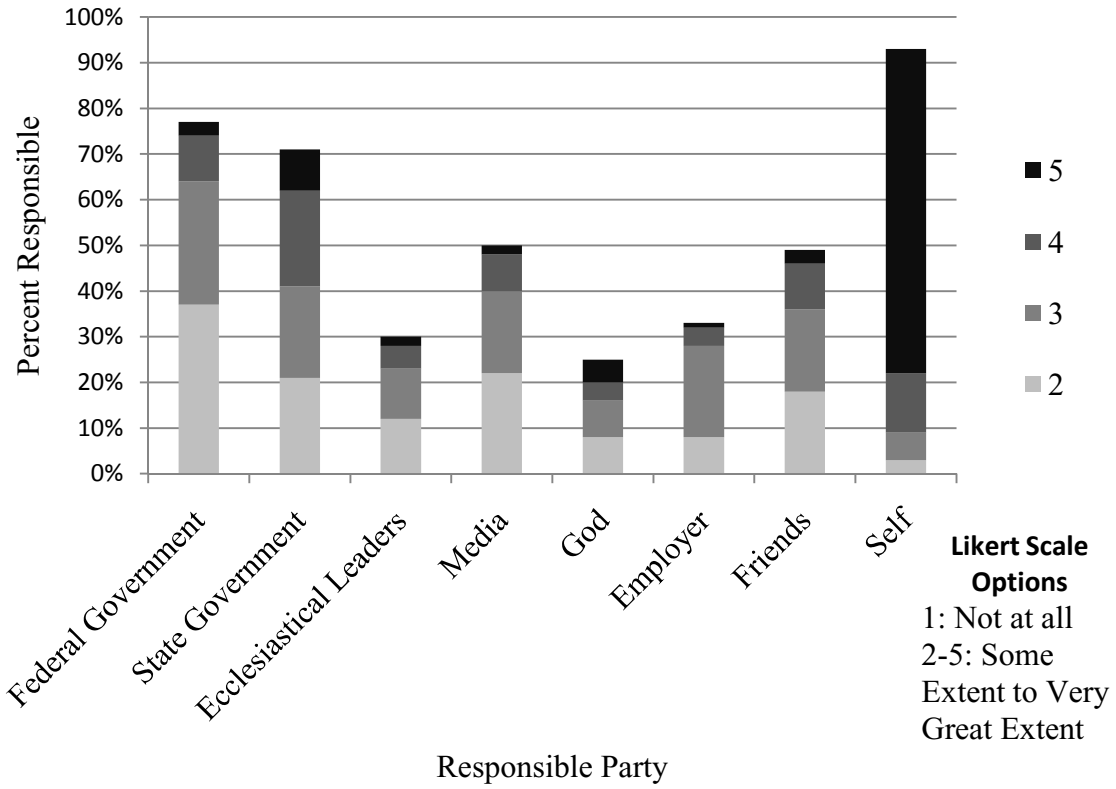

Figure 4.4 Percentage of responsibility for different parties for protecting the survey participants from an earthquake event.

from 2 to 5, in order to readily show the extent each group was responsible for protecting the survey respondents from an earthquake hazard. The "1" category or "not at all" or the Likert scale is shown as the difference between 100% and the top of each column for each group.

The vast majority of the survey respondents felt that they were most responsible for protecting themselves from an earthquake hazard. The total percentage for the "self" category is 93%, which is 16% higher than the next highest category. After "self" are the categories of federal government and state government, with 77% and 71% respectively. Every other category besides these three (self, federal government, and state government) agencies responsible for protection are below 50%. Media, such as newspapers, television, and radio are next with 50%, followed closely by friends with 49%. The next group responsible is one's employer, which had a 33% response. Ecclesiastical leaders as a group came in at 30%, while last of all, the category of God, had a response of only 25%.

Looking at the data by comparing the strongest response category (5 or very great extent) on the Likert scale yields some different results. By far, the strongest opinion about who is most responsible for protecting oneself from an earthquake hazard is oneself, with an overwhelming 71%. This is 62% above the next highest category and clearly shows that a majority of people believe that they themselves are most responsible for their own actions in preparing themselves from earthquake hazards. The next highest group in category 5 is state government with 9% response. Here the state government as a group moves to a higher position then federal government as explained above. The group God had the least percentage overall, but here under category 5 is third with 5%. Federal

government and friends both follow with 3% each. Next, at a 2% response are ecclesiastical leaders and the media. In the last position, the group employer, earned 1% of votes and therefore is deemed least responsible for protecting respondents from an earthquake hazard.

4.2.3 Personal Safety

This section describes the extent to which different responsible parties determine the personal safety of the survey participants during an earthquake. This is illustrated in Figure 4.5, in which each column is divided into sections arranged by the Likert scale options of 2, 3, 4, and 5; these correspond to the descriptions of "some extent" to "very great extent" respectively. The Likert scale option of 1, which is "not at all," is shown on the figure, by the difference of 100% and the top of each column.

Respondents believe that their personal safety is determined by oneself and one's immediate family. This category earned the highest percentage, with an extremely high 99%. The next two categories fall within 1% of each other and include friends, relatives, neighbors, and coworkers at 80% and local government at 79%. Luck or chance had a 76% response rate, while state and federal government agencies had a response of 72%. Luck or chance also had the second highest percentage for Likert scale option of 5, with 23%. The next lowest responsible party was the media that received a 62% response. Going down 25% to 37% is the responsible party of God. However, God has the third highest Likert scale option of 5 at 13%. The category that survey respondents attached with the lowest percentage of responsibility for their personal safety in an earthquake is that of ecclesiastical leaders, which had a 30% response rate. The category of

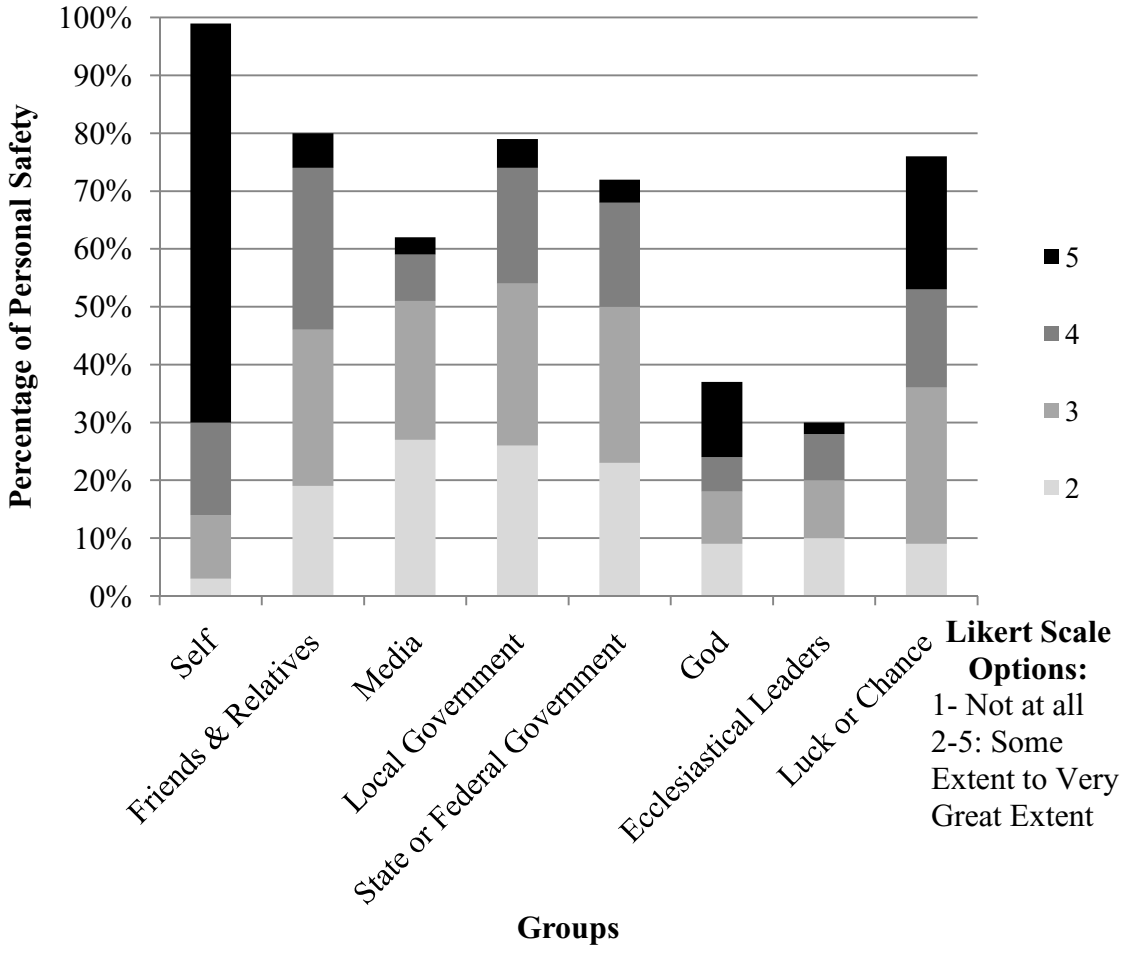

Figure 4.5 Percentage that the survey participants expect their personal safety to be determined by the actions of various groups in an earthquake.

ecclesiastical leaders also had the lowest percentage for Likert scale option 5 or "very great extent" of any other category, with a response of 2%.

4.3 Relationships

The first research question this study sought to answer was how variations in different seismic zones affect one's likelihood to perceived seismic risk and adopt earthquake hazard response. Figures 4.5 and 4.6 illustrate how the survey respondents believed to what extent their home is vulnerable to ground shaking and to liquefaction. Each figure divides the respondents living in high ground shaking seismic zones from those living in high liquefaction zones based on mailing address locations plotted on Utah state hazard maps. The graphs indicate the Likert scale responses by percentage for each number with 1 being "not at all" to 5 being "very great extent." In Figure 4.6 none of the survey participants responded with the belief that their homes were "not at all" vulnerable to ground shaking. Categories 2 and 3 start to slowly increase in the responses, while category 4 spikes at over 40% for survey respondents who live in both high ground shaking areas and high liquefaction areas. Finally around 30% of respondents believe that their home was vulnerable to ground shaking to a "very great extent." The majority of survey respondents (over 70%) thought their home is vulnerable to ground shaking. There was no difference in response related to which seismic zone the survey respondents resided in, as can be seen by the linear trend line that is identical for both the high ground shaking zone and the high liquefaction zone.

On the other hand, Figure 4.7 shows how vulnerable the survey respondents think their home is to liquefaction. Those residing in the ground—shaking zone responded

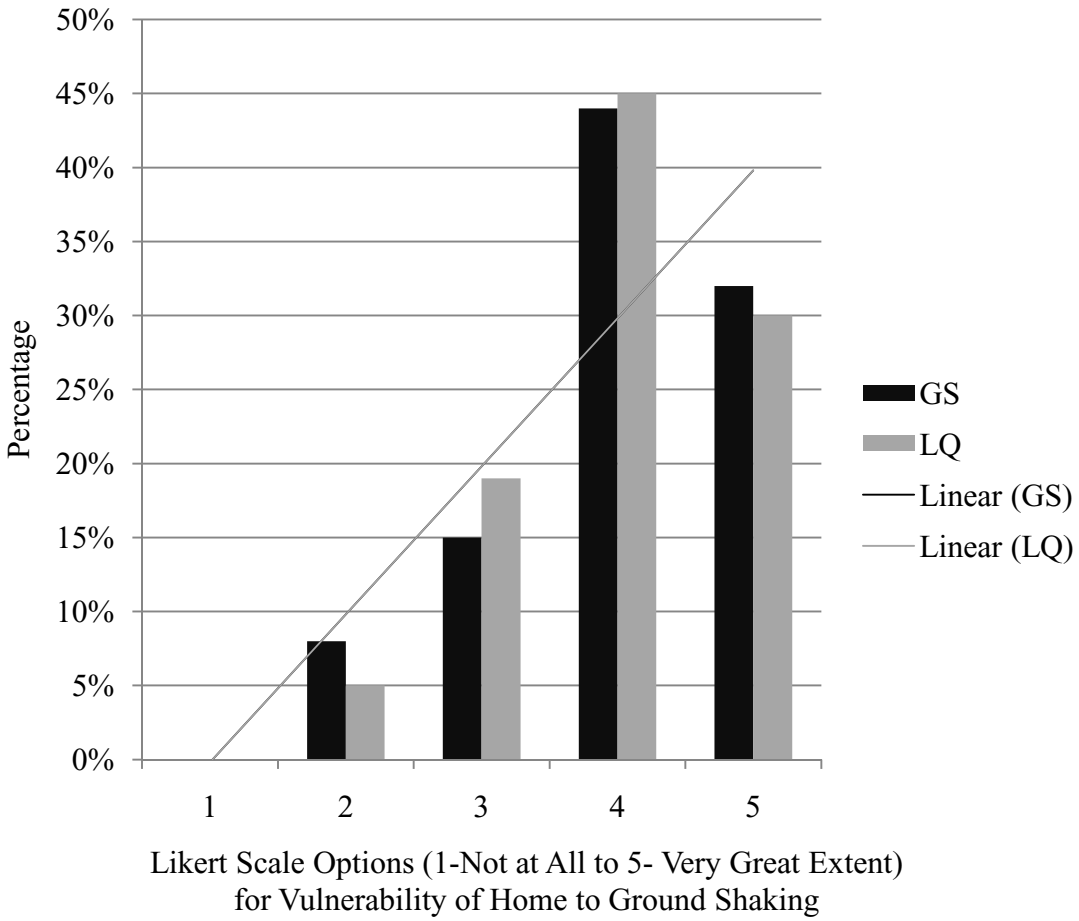

Figure 4.6 Vulnerability of home to ground shaking.

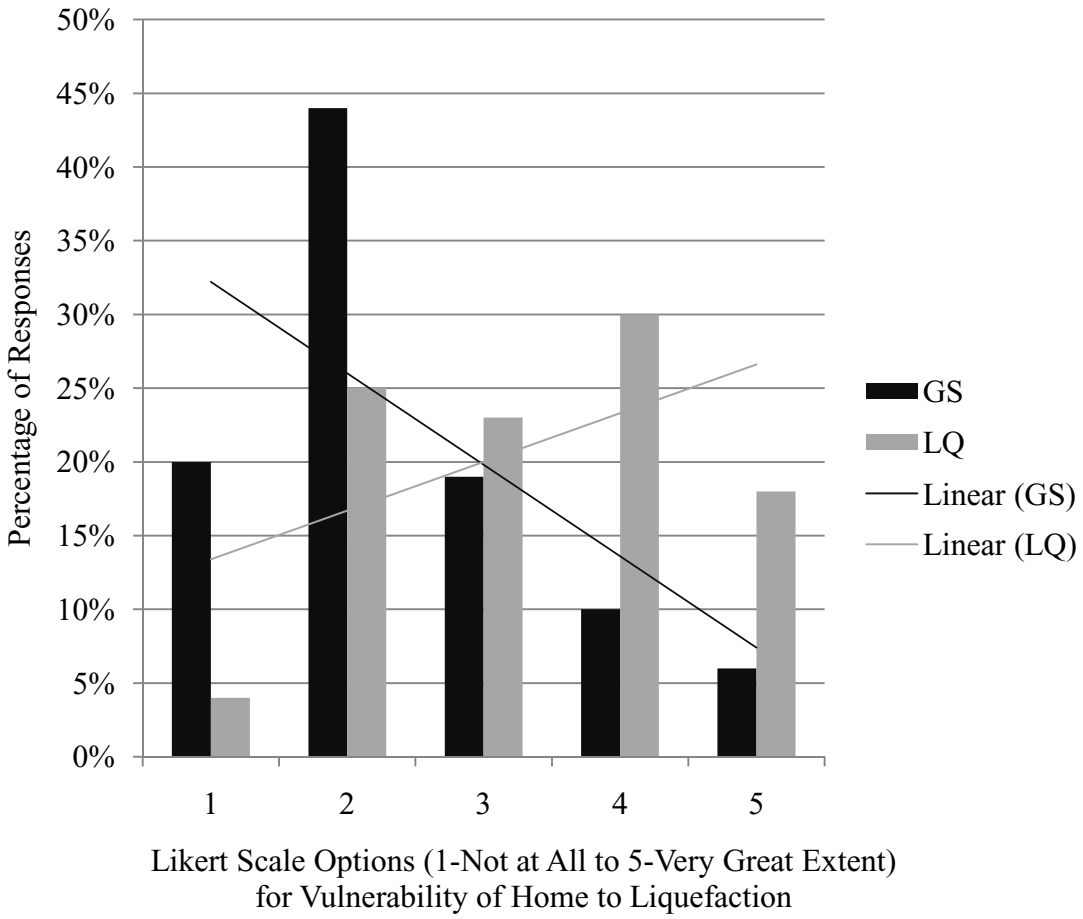

Figure 4.7 Vulnerability of home to liquefaction.

mostly with 1, 2, and 3 on the Likert scale. In other words, they thought that their homes were not very vulnerable to liquefaction. The survey respondents living in the liquefaction zone chose the Likert scale category of 4 most frequently. The linear trend line for the liquefaction residents shows an upward trend towards more vulnerability to liquefaction, which is opposite the linear trend for residents living in the ground shaking zone that shows an downward trend towards less vulnerability to liquefaction. In summary, both ground shaking and liquefaction zone respondents think they are highly vulnerable to ground shaking, but only the majority of liquefaction respondents feel they are highly susceptible to liquefaction.

In relation to how does living in different seismic zones affect the adoption of household seismic adjustments, Figure 4.8 illustrates the responses from question 6 on the survey about six household seismic adjustments. Question 6 on the survey asks whether households have earthquake emergency items, including a transistor radio, four gallons of water in plastic containers, a first-aid kit, a four day supply of dehydrated or canned food a fire extinguisher, and wrenches. Figure 4.8 consists of the six household seismic adjustments items made up of two columns. One column shows the response rate by percentage for adopting each household seismic adjustment for survey respondents living in high ground shaking areas, while the other column displays the responses by percentage for those living in high liquefaction areas.

Figure 4.8 shows that the survey respondents living in the high ground shaking areas had higher adoption percentages for four out of the six household seismic adjustments. These include having a radio, stored water, stored food, and a fire

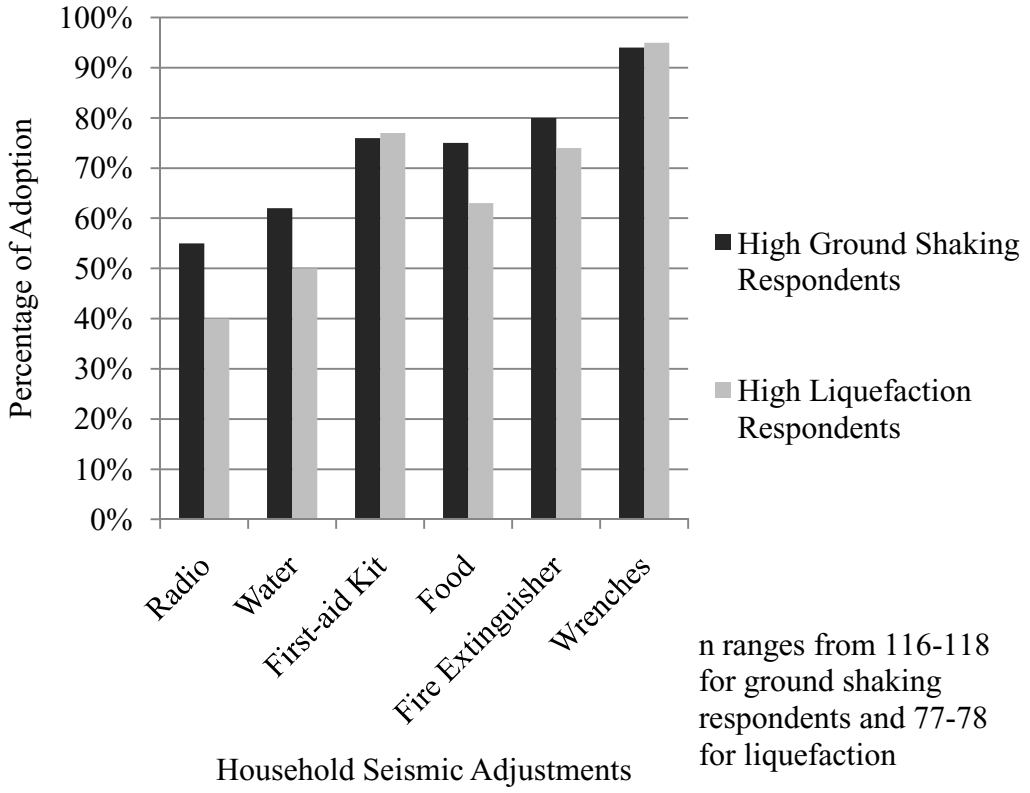

Figure 4.8 Comparison of adoption of six household seismic adjustments by seismic zone.

extinguisher. Having a radio showed the greatest difference between the two different seismic zones with a 15% difference (55% for respondents living in the high ground shaking area and 40% for those living in the high liquefaction area). A working radio is the lowest percentage adopted household seismic adjustment for both seismic areas. The two household seismic adjustments that survey participants living in the high liquefaction areas had a higher response rate were for having a first-aid kit and having wrenches to shut off utilities. However, both of these items only differed by one percentage point over those respondents living in the high ground shaking area. Overall, people living in the high ground shaking zone have adopted more household seismic adjustments then those living in the high liquefaction zone.

Rather than possessing certain household seismic adjustments as shown in Figure 4.8, Figure 4.9 deals with doing certain actions and is based on question 7 of the seismic risk perception and household adjustment survey. Question 7 includes seven earthquake household seismic adjustments that involve having accomplished something. These include the following: strapped water heater, installed latches to keep cabinets securely closed, developed a household earthquake emergency plan, learned where and how to shut off utilities, learned the location of nearby medical emergency centers, purchased earthquake insurance, and joined a community organization dealing with emergency preparedness. Figure 4.9 displays each of the seven household seismic adjustments from question 7 and is divided up into two columns for each seismic zones as in Figure 4.8. Each column displays the percentage of adoption of each of the seven adjustments.

Analysis shows that only two of seven household seismic adjustments were adopted at rates greater than 50% in both seismic zones. These two adjustments were

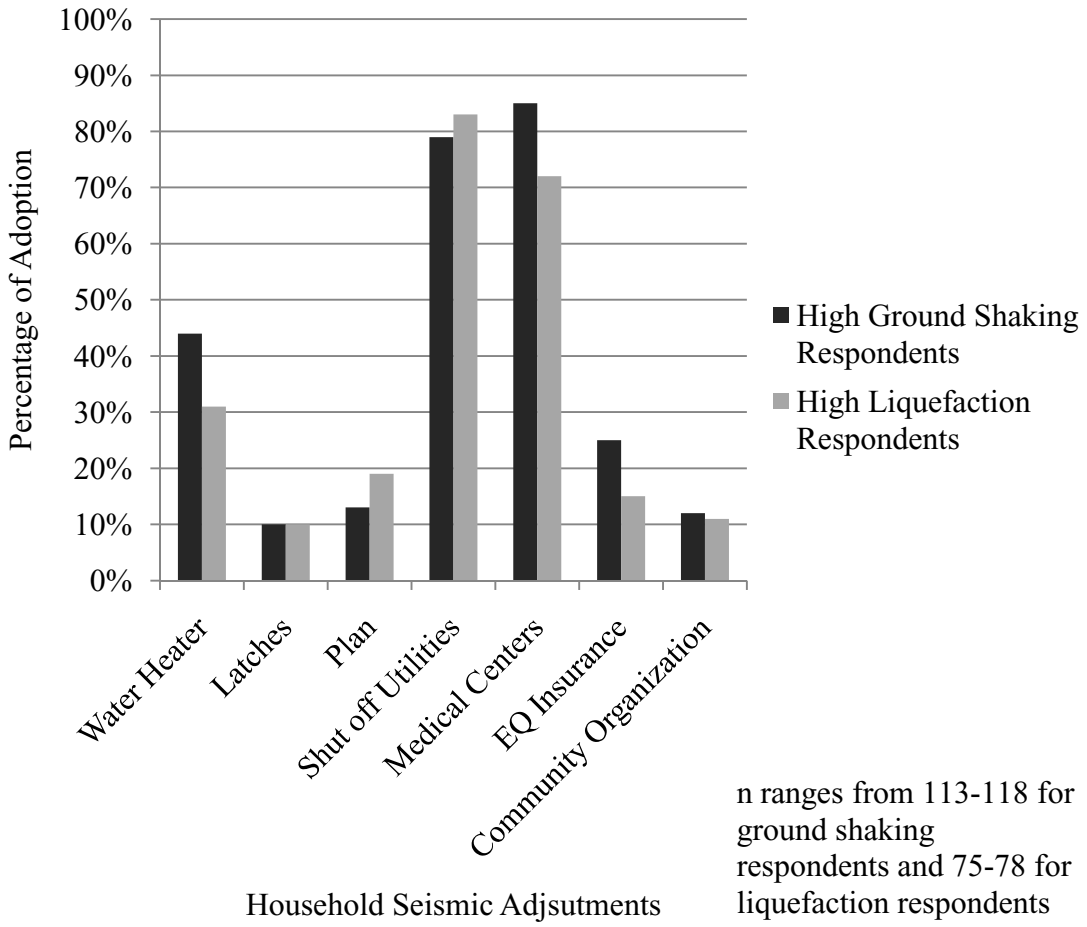

Figure 4.9 Comparison of seven household seismic adjustments by seismic zone.

having learned how to shut off utilities and learned the location of nearby medical emergency centers. Survey respondents living in the high ground shaking area adopted four out of the seven adjustments at a higher percentage than those survey respondents living in the high liquefaction area. The four adjustments include strapping one's water heater, knowing the location of nearby medical emergency centers, purchasing earthquake insurance, and joining a community organization dealing with emergency preparedness. Both strapping one's water heater and knowing the nearby location of medical emergency centers had a difference of 13% between the two seismic zones, while purchasing earthquake insurance had a 10% difference and joining a community organization only a 1% difference.

Two of the seven seismic adjustments were adopted at a higher percentage for those living in the high liquefaction zone over those survey respondents living in the high ground shaking zone. These two adjustments are having developed a household earthquake emergency plan and having learned how to shut off ones' utilities. The difference in percentage between the two seismic zones for these two seismic adjustments is 6% for the earthquake plan and 4% for the utilities.

Finally, the least adopted household seismic adjustment was installing latches on cabinets to keep them securely closed, which had a 10% adoption rate for survey respondents in both of the seismic zones. Survey respondents living in the high ground shaking zones adopted slightly more of the seismic adjustments involving actions, as compared to those survey respondents living in the high liquefaction zone.

4.3.1 Preparedness Level

In order to see a more comprehensive view of the preparedness level for the two different seismic zones, all six of the household earthquake seismic adjustments surveyed in question 6 are shown in Figure 4.8. All the seismic adjustments were combined into one column for each of the two seismic zones, as well as for all seven of the seismic adjustments displayed in Figure 4.9 or question 7 of the survey. This is illustrated in Figure 4.10. This figure shows a comparative preparedness based on adoption of all possible six seismic adjustments in Figure 4.8 by the survey respondents in each seismic zone.

This procedure was also conducted for the seven seismic adjustments in Figure 4.9. The survey respondents living in the high ground shaking zone had adopted 73% of all possible household seismic adjustments involving question 6 of the seismic risk perception survey and 39% of all possible seismic adjustments from question 7 of the survey. Those living in the high liquefaction zone had adopted 66% of all possible seismic adjustments from question 6 and 34% from question 7 on the survey. This amounts to a 7% difference for the first category and a 5% difference for the second.

Survey respondents living in the high ground shaking have adopted more household seismic adjustments than those living in the high liquefaction zone. The adoption rate of all 13 of the seismic adjustments by the survey respondents was combined for each seismic zone to get a more overall level of preparedness for residents of Salt Lake City. This is shown is Figure 4.11, in which each column displays the total number of adopted household seismic adjustments for each seismic zone. A percentage of 100 would mean that all possible seismic adjustments in the survey were adopted by

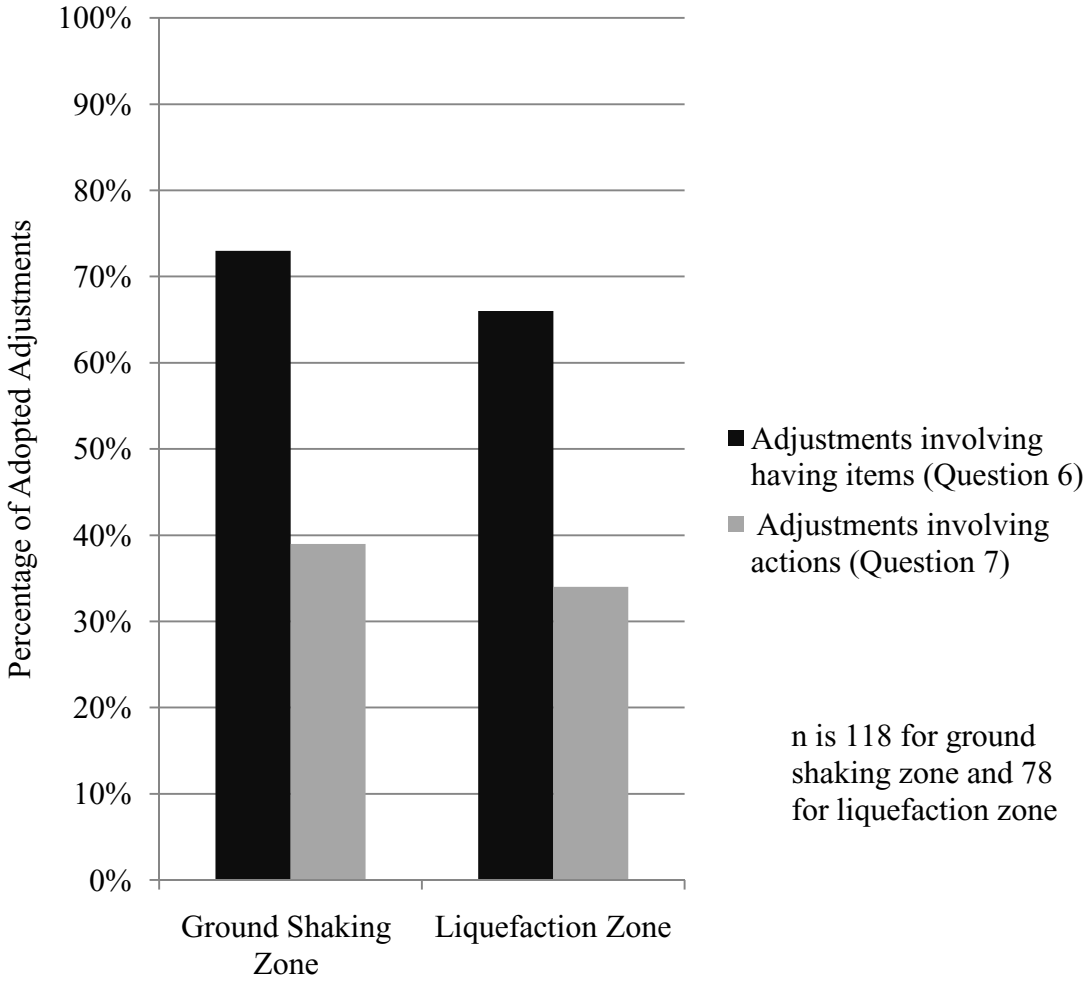

Figure 4.10 Comparison of household seismic adjustments by seismic zone.

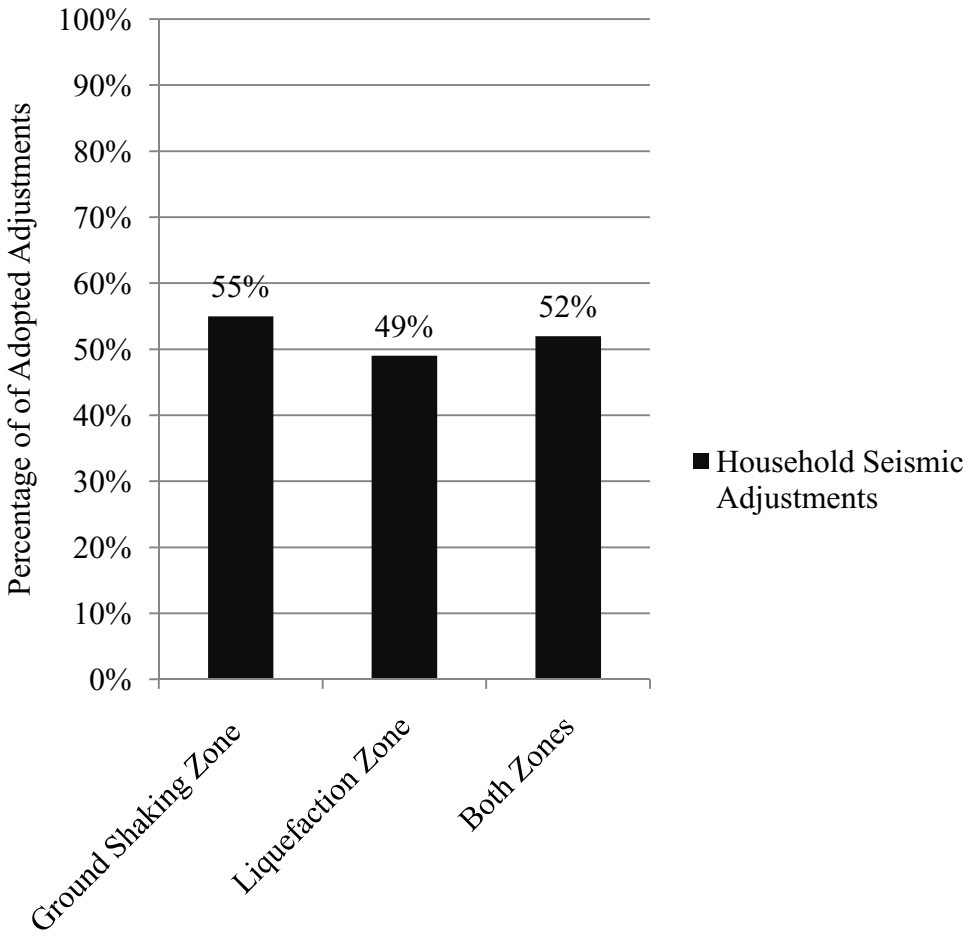

Figure 4.11 Percentage of adopted household seismic adjustments.

the survey respondents. The high ground shaking zone survey respondents had adopted 55% of the seismic adjustments while the high liquefaction zone survey respondents had adopted only 49% of the seismic adjustments items. This difference amounts to only 6%. Figure 4.11 also shows a column that combines the total adopted seismic adjustments for both seismic zones. The total percentage of household earthquake seismic adjustments adopted by the survey respondents in Salt Lake City was 52%. In other words, by using the 13 household earthquake seismic adjustments from question 6 and 7 of the seismic risk perception and household seismic adjustment survey as the criteria for the level of earthquake household preparedness, Salt Lake City residents are 52% prepared. The total average number of household seismic adjustments adopted by the respondents was 6.8 out of 13 as shown in Figure 4.12.

Of the 13 household seismic adjustments looked at in this study, the majority of these are also hazard adjustments for other hazards besides earthquakes. In order to see the preparedness level of the survey respondents exclusively for earthquakes, three of the household seismic adjustments that are associated only with earthquakes were analyzed: strapping ones water heater, developing a household earthquake emergency plan, and purchasing earthquake insurance. Installing cabinet latches to keep them securely closed was considered to be added, but upon further investigation it was discovered that 50% of the survey respondents who had installed cabinet latches also had children living at home, with 40% of those respondents having children under the age of 6. By taking those three seismic adjustments as the basis to assess earthquake preparedness level, the survey respondents were only 25% prepared, or in other words, the respondents had adopted on average less than 1 or 0.76 of the three seismic responses.

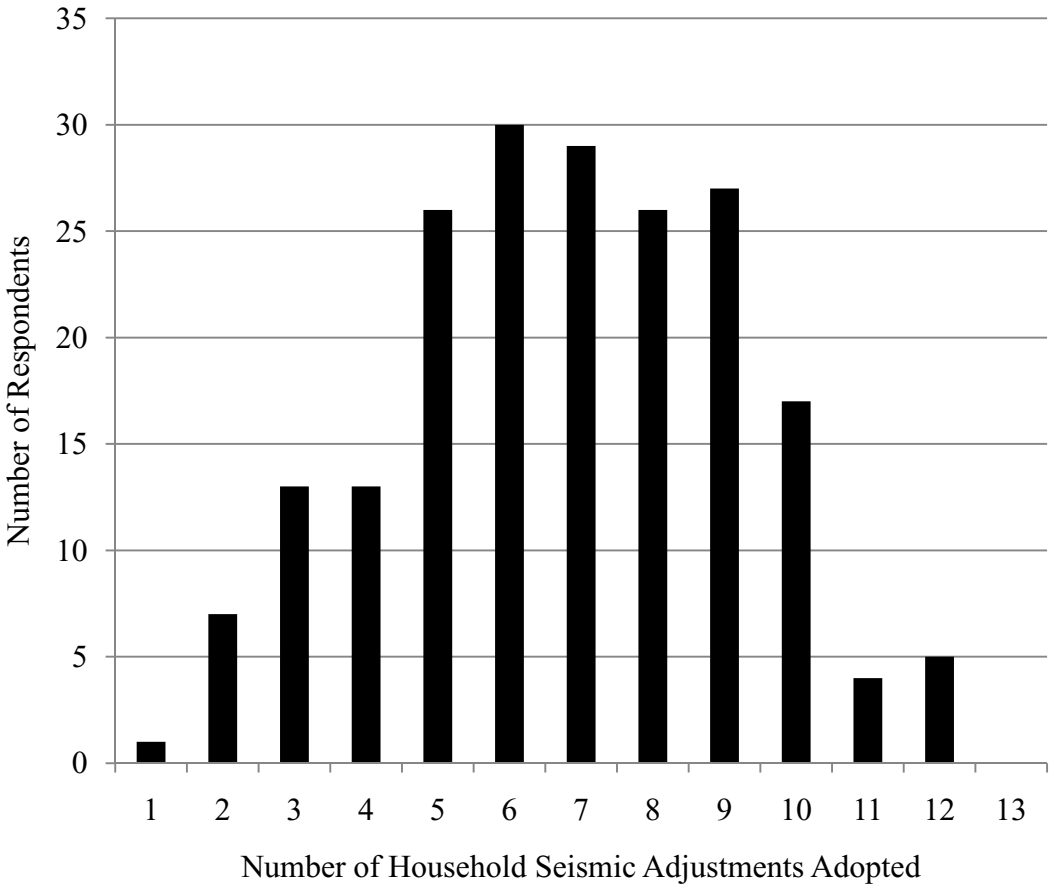

Figure 4.12 The number of adopted household seismic adjustments.

4.3.2 Population Demographics

The next research question this study dealt with is how variations in population demographics affect our perception of seismic risk and adoption of household seismic adjustments. This section will look at statistically significant relationships found analyzing the data from the seismic risk perception and household seismic adjustment survey.

The earthquake preparedness survey involved binary, categorical, and continuous data. One method chosen to analyze the data was the independent samples t-test. Various characteristics of the survey respondents were chosen such as gender and income and were compared with risk perception and emergency preparedness data. In addition, data on the adoption of household seismic adjustments were also compared with risk perception and demographic data.

The first category will describe the relationships found involving the adoption of certain household earthquake emergency actions with their effect on the perception of the level of preparedness to earthquakes. Using an independent sample t-test, the extent to which the survey respondents thought they were prepared for a major earthquake at their home was compared for the seismic adjustment of having a transistor radio and not having one. There was a significant difference in the perception of preparedness level for the seismic adjustment of possessing a transistor radio (mean (M)=2.58, standard deviation (SD)=0.90) and not possessing a transistor radio (M=2.17, SD=0.94); $t(194)$=-3.13, $p<0.01$. These results suggest that the possession of a transistor radio does have an effect on the preparedness level against earthquakes. In other words, when someone owns a transistor radio, they feel more prepared for an earthquake.

The extent to which the survey respondents thought they were prepared for a major earthquake to hit their home was also compared for the 12 remaining household seismic adjustments. Ten of the seismic adjustments had statistically significant relationships. However, four of those seismic adjustments, the significant value of Levene's test for equality of variance was less than 0.05, which indicates that the variability differs too much and is significantly different. These four seismic adjustments along with their p-values include: stored water ($p<0.01$), stored food ($p<0.01$), possession of wrenches to shut off utilities ($p<0.05$), and having learned how to shut off utilities ($p<0.01$). The remaining six seismic adjustments that had significant relationships when compared with preparedness level include possession of a first-aid kit, strapped one's water heater, installed cabinet latches, developed an earthquake emergency plan, purchased earthquake insurance, and joined a community organization dealing with earthquake preparedness.

The independent samples t-test statistical results for comparing the extent to which the survey respondents believed they were prepared for a major earthquake to hit their home with possession or absence of a first-aid kit are for a possession of a first aid kit (M=2.51, SD= 0.92) and for not possession of a first aid kit (M=1.96, SD= 0.91); $t(195)$=-3.63, $p<0.01$. The significant difference in preparedness belief and having strapped or not strapped one's water heater is for strapping one's water heater (M=2.70, SD=0.97) and not strapping one's water heater (M=2.18, SD=0.87); $t(196)$=-3.89, $p<0.01$. For installing latches (M=2.80, SD=1.01) and not installing latches (M=2.33, SD=0.93); $t(195)$=-2.12, $p<0.01$). For developing an emergency earthquake plan (M=3.03, SD=0.98) and not developing an emergency earthquake plan (M=2.25, SD=0.88); $t(195)$=-4.55,

$p<0.01$. For purchasing earthquake insurance ($M=2.85$, $SD=.096$) and not purchasing earthquake insurance ($M=2.26$, $SD= 0.90$); $t(194)=-3.68$, $p<0.01$. Finally for joining a community organization ($M=3.04$, $SD=0.89$) and not joining a community organization ($M=2.27$, $SD=0.91$); $t(187)=-3.93$, $p<0.01$. In summary, the results suggest that the adoption of the household seismic adjustments of possessing a first-aid kit, strapping one's water heater, installing cabinet latches, developing an earthquake emergency plan, purchasing earthquake insurance, and joining a community organization dealing with earthquake preparedness leads people to think that they are more prepared for a major earthquake to hit their home than those who have not adopted those measures.

The next category that was analyzed relates to comparing the extent to which the survey respondents think certain parties are responsible for protecting them from an earthquake hazard and the adoption of the seismic adjustments. There were four significant differences found using the independent samples t-test statistical method and they include: not storing four days of dehydrated or canned food, not owning a fire extinguisher, not owning wrenches to shut off utilities, and not knowing how to shut off one's utilities.

Comparing state and local government as a responsible party for protecting against an earthquake hazard with storing and not storing four days of canned or dehydrated food, the independent samples t-test results were for not storing food ($M=2.85$, $SD=1.47$), and for storing food ($M=2.36$, $SD=1.33$); $t(195)=2.27$, $p<0.05$. These results suggest that when someone has not stored at least four days of canned or dehydrated food the belief that the state and local government are responsible to protect from earthquakes increases. The next significant relationship was found by comparing the

responsibility of the media in protecting households against earthquakes with owning and not owning a fire extinguisher. The results were for not having a fire extinguisher (M=2.15, SD=1.28), and having fire extinguisher (M=1.78, SD=1.04); t(196)=2.03, p<0.05). This result suggests that when someone does not have a fire extinguisher the belief that the media is responsible to protect households from earthquakes increases.

Next is the comparison of the responsibility of friends, neighbors, relatives, and coworkers in protecting against earthquakes with owning and not owning wrenches to shut off utilities. The results were for not owning wrenches (M=2.64, SD=1.29) and owning wrenches (M=1.84, SD=1.16); t(195)=2.20, p<0.05. This suggests that when someone does not own wrenches to shut off utilities the belief that friends, relatives, neighbors, and coworkers are responsible for protecting against earthquakes increases.

Finally, a significant relationship was found by comparing the responsibility of state and local government in protecting against earthquakes with knowing and not knowing how to shut off one's utilities. The results were for now knowing (M=3.00, SD=1.41) and for knowing (M=2.38, SD=1.36); t(195)-2.55, p<0.05. This indicates that when someone does not know how to shut their utilities off the belief that the state and local government are responsible for protection against earthquakes increases.

Gender was the next category that was found to contain several significant relationships while conducting independent samples t-tests on the data. All of the significant relationships relate to the female gender. The first relationship suggests that when one is a female, the likelihood of thinking in the next 10 years there will be an earthquake that will cause major damage to one's home increases. The results are for females (M=2.97, SD=1.07) and for males (M=2.66, SD=0.99); t(194)=-2.08, p<0.05.

Next is that the likelihood of thinking that an earthquake will cause injury to oneself or family in the next 10 years is higher among the female population. The results are for females (M=2.65, SD=0.95) and for males (M=2.37, SD=0.99); t(194)=-2.05, p<0.05. The next significant relationship suggests that when one is a female the belief that the state and local government are responsible for protection in an earthquake increases. The results are for females (M=2.73, SD=1.42) and for males (M=2.30, SD=1.33); t(194)= -2.23, p<0.05. Finally, the results suggest that the extent one expects personal safety to be determined by the actions of the local media, local government agencies, and state or federal government agencies increases when one is female. The results are for media for females (M=2.38, SD=1.11) and for males (M=1.76, SD=1.06); t(194) =-4.03, p<0.01; for local government agencies for females (M=2.76, SD=1.18) and for males (M=2.34, SD=1.20); t(194)=-2.46, p<0.05, and for state or federal government agencies for females (M=2.70, SD=1.21) and for males (M=2.17, SD=1.20); t(194)=-3.08, p<0.01.

The last category that yielded statistically significant results was the issue of vulnerability to one's house. The following will describe the relationships and list the independent samples t-test results. The results suggest that when one owns a house, the extent to which one thinks their house is vulnerable to liquefaction increases. The t-test results are for owners (M=2.84, SD=1.21) and for renters (M=1.95, SD=1.47); t(195)=2.84, p<0.01. Next is that when one does not own wrenches to shut off utilities, the likelihood of one thinking that there will be a major earthquake that will cause major damage to one's house in the next 10 years increases. The results are for those who do not own wrenches (M=3.72, SD=0.90) and for those who do own wrenches (M=3.17, SD=0.87); t(195)=2.05, p<0.05.

The following results suggest that the degree one perceives one's house will survive a major earthquake increases when one knows the location of nearby medical emergency centers, one does not have children under the age of six, and when one's immediate family's property has been damaged in a n earthquake. The t-test results are for those who know the location of the emergency centers (M=2.69, SD=0.90) and those who do not (M=2.17, SD=0.92); $t(195) = 3.29$, $p<0.01$. For those who do not have children under the age of six (M=2.65, SD=0.92) and those who do (M=2.30, SD=0.85); $t(190)=2.09$, $p<0.05$, and for those whose immediate family was damaged in an earthquake (M=2.95, SD=1.00) and those whose family property was not damaged in an earthquake (M=2.54, SD=0.91); $t(192)=-1.99$, $p<0.05$. Lastly, the results suggests that when the property of one's friend, relative, neighbor, or coworker have not been damaged in an earthquake the likelihood of thinking one's house in more vulnerable to earthquake damage than surrounding houses increases. The t-test results are for those with no damage to the property of one's friend, relative, neighbor, or coworker (M=3.30, SD=0.87) and for damage to the property of one's friend, relative, neighbor or coworker (M=2.90, SD=0.88); $t(192)=2.58$, $p<0.05$. See Table 4.2 for a summary.

4.3.3 Type of House

The third question addressed in this research dealt with the type of one's house and included the age, the floor plan, and the construction type of the house. In relation to the age of one's house, three statistically significant relationships were found. One relationship was that those whose houses were built before 1975, perceived that their homes were more vulnerable to earthquake damage as compared to neighboring houses.

Table 4.2 The independent samples t-test results and their p-values.

Hazard Adjustment	Think More Likely	t-test
Have radio	Prepared for earthquake hazard	$p<0.01$
Have first-aid kit	Prepared for earthquake hazard	$p<0.01$
Strapped water heater	Prepared for earthquake hazard	$p<0.01$
Installed cabinet latches	Prepared for earthquake hazard	$p<0.05$
Have earthquake plan	Prepared for earthquake hazard	$p<0.01$
Have earthquake insurance	Prepared for earthquake hazard	$p<0.01$
Joined community organizatic	Prepared for earthquake hazard	$p<0.01$

Hazard Adjustment	Think More Responsible for Protection from	t-test
No stored food	State and local government	$p<0.05$
No fire extinguisher	News-media	$p<0.05$
No wrenches	Friends, neighbors, and relatives	$p<0.05$
Don't know shut off utilities	State and local government	$p<0.05$
No earthquake insurance	Federal government	$p<0.05$

Gender	Think More Likely	t-test
Female	Earthquake will cause major damage to home in 10 years	$p<0.05$
Female	Earthquake will cause injury to self and family in 10 years	$p<0.05$
Female	State and local government responsible for protection from EQ*	$p<0.05$
Female	Local news-media determines personal safety more in EQ	$p<0.01$
Female	Local government determines personal safety more in EQ	$p<0.05$
Female	State and federal government determines personal safety in EQ	$p<0.01$

Adjustment/Characteristic	Think More Likely	t-test
Own home	Home is vulnerable to liquefaction	$p<0.01$
No wrenches	EQ cause damage to home in 10 years	$p<0.05$
Don't know shut off utilities	Media determines personal safety in	$p<0.05$
Know location of hospitals	House will survive a major earthquake	$p<0.01$
Joined community organization	Friends determine personal safety in	$p<0.05$
Have no children under age 6	House will survive a major earthquake	$p<0.05$
Property damaged in EQ	House will survive a major earthquake	$p<0.05$
Friends' property damaged in EQ	Neighbors' homes less vulnerable to EQ	$p<0.05$

*EQ is abbreviated for earthquake.

The t-test results for houses built before 1975 were (M=3.28, SD=0.86) and for houses built after 1975 (M=2.68, SD=0.80) where $t(195)=3.31$, $p<0.01$. The next relationship found involved the respondents whose houses were built before 1975, in which they thought that the state and local government were more responsible for protecting against earthquakes. The results show for houses built before 1975 (M=2.40, SD=1.34) and for after 1975 (M=3.24, SD=1.48); $t(195)=-2.88$, $p<0.01$. Finally, respondents whose houses were built after 1975 thought more likely that their house will survive a major earthquake. The results for houses built after 1975 (M=3.24, SD=0.83) and for before 1975 (M=2.49, SD=0.90) where $t(195)=-3.90$, $p<0.01$). Additionally, no statistically significant t-test relationships were found when analyzing the data in regards to the construction material of the respondents' houses or between the type or floor plan of house.

CHAPTER 5

DISCUSSION

5.1 Adoption Rate of Seismic Responses

The percent of households that reported adoption of the 13 different household seismic adjustments that were investigated in this study are displayed in Figure 4.3 and Table 4.1. The high percentage of households owning wrenches that can shut off one's utilities (94%) and of knowing how to shut off one's utilities (80%) was not unexpected. This is due to the fact that 90% of the survey respondents own their home and it is generally expected that homeowners own basic tools like wrenches and know how to shut off their utilities in Salt Lake City. In addition, these two responses cost little or nothing. The high percentage of people knowing how to shut off their utilities was consistent with Garcia (1989) who also reported an 80% adoption rate for Irvine, California. Davis (1989) reported a 63% adoption rate in San Bernadino, Long Beach, and Whittier, California. Farley et al. (1993) reported a 66% adoption rate before a predicted earthquake by Iben Browning in the New Madrid fault area and a 87% after the prediction. A surprising finding was the relatively low percentage (79%) of households reporting knowing the location of nearby medical emergency centers. In other words, one-fifth of the survey respondents did not know the location of nearby hospitals or

medical centers. This could be due in part of a misunderstanding of the question, which mentioned “medical emergency centers,” but not “hospitals.” Perhaps this terminology was misleading, as it could have been narrowly interpreted as specially designated places of gathering for medical attention following an emergency like an earthquake. A look at the length of residence time the survey respondents have lived in their houses shows only 4% with 1 year and another 4% with 2 years. Twenty-two percent of the respondents have lived in their home for 5 years and under. The average length of residence by respondents in their households was 14 years. In addition, the majority of those who did not know the location of nearby medical emergency centers did not live real close to any hospitals. If the 20% is not a result of a misunderstanding of this question then the fact that one fifth of the residents did not know the location of nearby medical emergency centers is alarming and could be a focus for emergency planners to address.

The 21% adoption rate of earthquake insurance reported by respondents is somewhat surprising, especially since no major earthquake has hit Salt Lake City during its modern settlement. However, the fact that one-fifth of the survey respondents have purchased earthquake insurance demonstrates that earthquake hazards are a prominent concern among residents of Salt Lake City. Other emergency preparedness studies for earthquakes report similar findings for earthquake insurance in California: Palm et al., 1990 – 33%, Garcia, 1989-26%, Davis, 1989-45% and Sullivan et al., 1976-22%. However, these studies were conducted in areas with historic earthquakes. One reason why more people may not have purchased earthquake insurance is the prevalent belief that it is too expensive. Palm et al. (1990) found that the top two reasons why people do not buy earthquake insurance is the belief that it is not necessary and its high cost. In fact,

a study by Kunreuther et al., (1978) discovered that the majority of those without earthquake insurance overestimate its cost. In addition, a later study found that an overestimation of the cost of earthquake insurance by 50% or more was reported by more than 40% of those who did not have earthquake insurance (Palm et al., 1990).The fact that a majority of the respondents in Salt Lake City reported having a fire extinguisher (77%), first-aid kit (76%), stored food (70%) and stored water (58%) is not unexpected since all of these items apply for various hazards. These percentages are comparable with other studies in which one reported the storage of food and water at 44% before a hazard awareness campaign and 75% after and the storage of emergency equipment at 50% before and 81% after an earthquake (Mileti & Darlington 1995, 1997) and another study that reported the storage of food and water at 51% before a predicted earthquake and 70% after the prediction (Farley et al., 1993).

The 49% adoption rate reported for those who have a radio with spare batteries in their homes is a little surprising. Emergency personnel who rely on the radio as a form of communication to broadcast warnings, instructions or information will only reach about one half of the residents in Salt Lake City. Other communication methods such as the internet, phones, and television may not function following a major earthquake. Edwards (1993) found that 70% of her respondents had a battery-operated radio, which may indicate that the possession of battery-operated radios has declined in the last two decades. This may be due to the popularity of devices like smart phones that access the internet and mp3 players, which allow people to listen to the radio.

The low adoption rates reported for strapping water heaters 38%, developing an earthquake plan (17%), joining a community organization dealing with earthquakes

(13%), and installing cabinet latches (10%) are not surprising since most of these adjustments are specific to earthquakes, inconvenient, or time consuming. Similar findings are reported by Farley et al. (1993): the least adopted seismic adjustment was securing objects, which ranged from 17% before Browning's earthquake prediction and 27% after the prediction. Lindell and Prater (2000) found that low adoption rates of seismic adjustments to earthquakes are common even after years of major earthquakes.

5.2 Responsibility for Earthquake Hazards

The results section reported on various groups held to be responsible for protecting households from an earthquake as well as for determining people's personal safety from earthquakes (see Figures 4.3 and 4.4). The high percentage reported for self as the group most responsible for protection (93%) and for determining personal safety (99%) was not surprising. Garcia (1989) found a high percentage (98%) of respondents assigning oneself as responsible for earthquake preparedness. This emphasis on individuals being most responsible for preparing and dealing with earthquake hazards was lower 30 years ago in research which found only 10% of respondents believed households were responsible for coping with earthquakes (Jackson, 1977, 1981). The belief by the overwhelming majority of respondents that they are most responsible for earthquake protection and safety should be a primary focus for emergency personnel, government officials, and the media. These previous studies also report respondents believing that government shares some responsibility for coping with earthquakes with federal government at 54%, state government at 19% and local government at 23% (Jackson, 1977, 1981) and for the local government to carry emergency supplies for

households at 68% (Garcia, 1989). The lower percentages in these studies compared to that found in this study with the responsibility for protection of earthquake for federal government at 77% and for state government at 71% and for determining the personal safety of individuals in an earthquake by the local government at 79% and for the federal and state government at 72% may be due to the difference of questions asked in the studies, which is a concern when comparing similar studies on seismic adjustments (Perry, 1990). However, this study in conjunction with past research indicates that most people rely on the government to protect and offer aid for earthquake hazards even in an area which has never had a major historical earthquake.

The high percentages for respondents who believe that friends, relatives, neighbors, and coworkers and media are responsible parties for protection against earthquakes (49% and 50%, respectively) and for determining one's personal safety in an earthquake (80% and 62%, respectively) are consistent with studies that report that both of these groups influence how individuals deal with earthquake hazards (Lindell & Perry, 2000). These high percentages for media indicate that a large percent of people rely on the media for information about earthquakes. The media is a channel through which emergency personnel may focus to reach a large percentage of the population. This effort through the media may even reach more people because 80% of the respondents believed friends, relatives, neighbors, and coworkers influence them in regards to determining their personal safety from earthquakes.

The low percentages for ecclesiastical leaders and God as responsible parties for protection from earthquakes (30% and 25%, respectively) and for determining the personal safety of the respondents in an earthquake (30% and 37%, respectively) is

somewhat surprising. This is due to a long time emphasis on emergency preparedness by the dominant religious organization, headquartered in Salt Lake City. However, these low percentages may not be of reflection of the motives or influences on how people perceive and prepare for earthquakes. Further research is needed in this area.

5.3 Vulnerability of Home

The two seismic zones in Salt Lake City shared no significant relationships in the perception the respondents had of the vulnerability of their homes to ground shaking. The fact that both the high ground shaking zone respondents and the high liquefaction zone respondents have identical increasing vulnerability linear trends (see Figure 4.6) leads to the conclusion that regardless of the type of high hazard seismic one resides in, people generally perceive that their house is vulnerable to ground shaking to a great extent. This is also supported by the observation that no respondents thought that their homes were "not at all" vulnerable to ground shaking. However, 76% of the high ground shaking residents and 75% of the high liquefaction respondents thought that their homes were vulnerable to ground shaking to a great extent or greater.

In contrast, the results for the perceived vulnerability of the respondents to liquefaction were somewhat surprising. It was anticipated that liquefaction from earthquakes would not be well known, but the results show just the opposite, as can be seen by how the crossed linear trend lines in Figure 4.7 are as explained in the results section. The responses of the respondents in the high liquefaction zone show an increasing trend towards increasing vulnerability of their homes to liquefaction while the responses of the respondents in the high ground shaking zone show a decreasing trend

towards decreasing vulnerability of their home to liquefaction. In other words, 4% of the high liquefaction respondents thought that their houses were not at all vulnerable to liquefaction, whereas 20% of the high ground shaking respondents thought so. In addition, 48% of the high liquefaction respondents thought that their houses were to a great extent or greater vulnerable to liquefaction extent or greater, while only 16% of the high ground shaking respondents thought so. Respondents in the high liquefaction zone seem to know that they are in this zone and respondents in the high ground shaking zone seem to know that they are not as susceptible to liquefaction. Even though no historic earthquake has occurred in Salt Lake City, the results of this study indicates that residents are vastly aware of the possibility and likelihood of major earthquakes along the Wasatch Front as well as some of the potential effects like liquefaction and the threats these pose to their homes. They also seem to be well informed about earthquakes. However, further research is needed to ascertain if the residents of Salt Lake City are seeking earthquake information themselves or whether emergency personnel, government officials, the media, etc. are communicating effectively.

5.4 Preparedness and Seismic Zones

Respondents living in the ground shaking zone have adopted more household seismic adjustments than those respondents living in the liquefaction zone. Although the difference is subtle, it in part reflects differences in education, income, presence of children at home, and marital status. These demographic characteristics for the ground shaking respondents in relation to the liquefaction respondents include college graduate or greater-87% to 53%, income greater than $60,000-69% to 41%, presence of children at

home-42% to 29%, and married-69% to 63%. All of these demographic characteristics have been correlated with adoption of seismic adjustments for households (Dooley et al., 1992; Edwards, 1993; Russell et al., 1995). However, residence tenure and ownership, which have been correlated with a higher adoption rate of seismic adjustments (Dooley et al., 1992; Russell et al., 1995) were actually lower in the ground shaking zone in Salt Lake City. These mixed results are consistent with the pattern of correlation found in studies over the last several decades (Lindell & Perry, 2000).

The finding that the average number of household seismic adjustments adopted was 6.8 out of 13 or 52% is difficult to compare to other studies, because there is no standard in the number and type of household seismic adjustments used by researchers in the field (Lindell & Perry, 2000). Perry and Lindell (2008) found a mean of 3.0 out of 7 or 43% adoption rate of household seismic adjustments. Other studies have seismic adjustments that range from 1 to 17 or use spontaneously mentioned questions (Lindell & Perry, 2000). The finding that just over half of the 13 seismic adjustments have been adopted on average indicates that the respondents are earthquake aware and are consciously doing something to prepare against a hazard like an earthquake. Most of the seismic adjustments used in the study are related to multiple hazards, yet all of them are associated with earthquake preparedness. The result that 0.76 out of 3 or 25% of the three adjustments exclusively for earthquakes had been adopted on average does not fully describe the preparedness level of the respondents to an earthquake hazard. Further research is needed into what hazards specifically motivate people to adopt certain adjustments. In addition, more studies addressing multiple hazards are needed to get a more comprehensive view.

The independent samples t-test results were not surprising that found having a radio, a first aid-kit, strapping one's water heater, installing cabinet latches, having an earthquake plan, purchasing earthquake insurance, and joining a community organization dealing with earthquake preparedness lead people to think that they are more prepared for an earthquake than those who have not adopted such seismic adjustments. It would be expected and intuitive that people who have adopted some seismic adjustments would think themselves more prepared than those who have not prepared.

On the same note, it was also not unexpected that those who have not stored food, do not have a fire extinguisher, have no wrench to shut off utilities, do not know how to shut off utilities, and have no earthquake insurance would think that federal, state, and local governments, the news media, and friends, relatives, and neighbors are most responsible for protection against earthquakes as compared to those who have adopted seismic adjustments. It would seem to those who have not prepared as much would rely upon outside sources for help. Mullis and Davis (1995) research suggested that the adoption of seismic responses had a significant relationship with perceived personal responsibility in protecting against earthquakes. In addition, low levels of adoption of seismic responses were suggested as a result of the belief of who was responsible for dealing with earthquakes (Jackson, 1977, 1981). In Jackson's research, federal, state, and local governments were chosen most frequently as being responsible for dealing with earthquakes.

The survey indicates that females in Salt Lake City are more likely to perceive high risk of major damage to the home, as well as personal injury from an earthquake. Female respondents also assign more responsibility to federal, state, local governments,

and local news media for protecting and determining one's personal safety in. This finding is consistent with other research (Flynn et al, 1994; Morrow, 1999).

Salt Lake City respondents who own their own home are more likely to think that their home is vulnerable to liquefaction than those who rent. This correlation may be potentially explained by the fact that 95% of the respondents living in the liquefaction zone owned their home; only 86% of the respondents living in the ground shaking zone were home owners. In addition, those who own a home may take more responsibility over their place of residence than those who rent.

The finding that those with no wrenches tend to think it more likely that a major earthquake will cause major damage to their home in the next 10 years is not unexpected. It would be anticipated that those who have not prepared very much for hazards would fear more of the consequences and would look more to outside sources for help in coping with them (Jackson, 1977, 1981; Mullis and Davis, 1995).

The survey results suggest that those who know the location of medical emergency centers tend to perceive that their home will survive a major earthquake. This result seems a bit unusual. It may be a consequence of the belief that as hazard awareness increases, fear of major consequences decreases. It is not surprising that those who have joined a community organization dealing with earthquake preparedness tend to view that the actions of friends, relatives, neighbors, etc. determine their degree of personal safety during an earthquake. Community organizations in Salt Lake City like CERT (Community Emergency Response Teams) rely upon friends and neighbors in responding to earthquakes (CERT, 2004). The result that those with no children under the age of 6 tend to think their houses will survive a major earthquake is consistent with research

indicating that families with children are more vulnerable and must overcome greater obstacles during hazards (Morrow, 1999).

It was not unexpected that respondents who had past property damaged in an earthquake tended to think that their houses will survive a major earthquake. It is intuitive to think that if one had experienced an earthquake in the past, with no devastating effects, then one would survive another one. In addition, if the property of a respondent's friend was damaged in an earthquake, the respondent would view his or her home as vulnerable to earthquake damage. It would be anticipated that people whose friend's property had been damaged in an earthquake would personalize the risk more to his or her circumstances.

5.5 Weaknesses and Strengths

Although the surveys were sent out randomly in this study, the population who returned surveys does not reflect a random sample of the Salt Lake population; instead, the respondent population over represents Caucasians, homeowners, high income levels, and college graduates. This may introduce some bias into the results. Future studies in Salt Lake City should include a survey written in Spanish, and divide the categories related to income levels to fit the typical demographics of this area better. However, this study does represent the male to female ratio well. Since no study such as this has been conducted in Salt Lake City, this research lays some groundwork for future studies to be conducted in this part of the United States. However, survey data are only opinioned based and cannot be considered true or false (Snuffer, 2011). Survey data only tells one what has or is happening. These opinioned based data change and are unstable. They

cannot inform someone what should happen in the future (Snuffer, 2011). This work also looked at how ground shaking zones, liquefaction zones, and type of houses affect adoption of seismic adjustments and risk perception. This research has also looked at an area that has experienced no major earthquakes in historic times, whereas most other research deals with regions that have experienced major earthquakes since modern settlement.

Lindell and Perry (2000) and Perry (1990) noted that there is no standard to the number of household seismic adjustments looked at by researchers and that this variation of seismic adjustments can lead to difficulties in comparing and interpreting the data. In addition, this research only focused on seismic adjustments that were relatively easy to adopt by households. Further research could look at those adjustments such as securing one's house to its foundation that take greater time, cost and inconvenience (Lindell & Prater, 2002). This research also falls in with this issue, but is based as previous studies and can still be useful. This study evaluated the actual adoption of seismic adjustments at the household level, but did not assess what influences people to adopt those seismic adjustments. The 52% level of preparedness found in this research, even though no major earthquake has hit Salt Lake City in recent times, may be a consequence of several factors, including the influence of religion, which has a major impact in this area and stresses practices of emergency preparedness. Further investigation is recommended to better understand the causes of why people prepare for disasters in Salt Lake City.

CHAPTER 6

CONCLUSION

This study was able to assess demographic characteristics, seismic zones, and house characteristics, in relation to risk perception and the adoption of 13 household seismic adjustments by households surveyed in Salt Lake City. Several conclusions can be drawn from this research. Despite a lack of a major historic earthquake since the area was settled in 1847, most Salt Lake City residents are aware of the earthquake threat posed by the WFS, and many households have taken measures to become prepared. However, to avert a disaster, much more preparation is needed, especially for seismic adjustments such as strapping water heaters and tall furniture, installing cabinet latches, developing a household earthquake plan, purchasing earthquake insurance, and joining a community organization dealing with earthquake preparedness. In addition, this survey suggests one focus for emergency personnel and government officials is to inform the public about the location of places to receive medical attention following an earthquake. The vast majority of people responding to the study survey indicate that they relied upon themselves as being the most responsible party for dealing with earthquakes and have adopted the most seismic adjustments; however, this population still relies on help from government agencies in the case of a seismic event. This can help emergency personnel

focus their attention on personal responsibility. People living in the ground shaking zones of Salt Lake City have accomplished more preparation than those living in liquefaction zones. Also, respondents living in older houses perceive their houses as more vulnerable to earthquake damage. This study has added to the body of data and research on earthquake preparedness. However, instead of focusing on the West Coast or the New Madrid area it has looked at the Intermountain Seismic Belt region. The process by which households adopt seismic adjustments and reduce vulnerability to earthquakes is complex and more research is needed, especially as more and more people live in regions with earthquake risk.

APPENDIX

SURVEY OF EARTHQUAKE PREPAREDNESS ACTIONS

The following survey was used in this thesis. This survey was adapted from a survey courtesy of Michael K. Lindell, Director of the Hazards Reduction and Recovery Center at Texas A&M University.

1.	How likely do you think it is that in the next 10 years there will be an earthquake that will cause...	**Not at all likely**				**Almost a certainty**
b.	major damage to your home	**1**	**2**	**3**	**4**	**5**
c.	injury to you or members of your immediate family	**1**	**2**	**3**	**4**	**5**
d.	disruption to your job that prevents you from working	**1**	**2**	**3**	**4**	**5**
e.	disruption to your shopping and other daily activities	**1**	**2**	**3**	**4**	**5**

2.	Compared to other buildings in your area, how vulnerable to earthquake damage do you think is your	**Much less than average**				**Much more than average**
a.	home	**1**	**2**	**3**	**4**	**5**
b.	workplace	**1**	**2**	**3**	**4**	**5**

3.	To what extent do you think you are prepared for a major earthquake to hit your home?	**Not at all**				**Very great extent**
		1	**2**	**3**	**4**	**5**

4.	To what extent do you think your home is vulnerable to	**Not at all**				**Very great extent**
	liquefaction (ground soil liquefying)?	**1**	**2**	**3**	**4**	**5**
	ground shaking	**1**	**2**	**3**	**4**	**5**

5.	To what extent do you think that each of the following is *responsible for protecting you from* earthquake hazard?	**Not at all**				**Very great extent**
a.	federal government	**1**	**2**	**3**	**4**	**5**
b.	state and local government	**1**	**2**	**3**	**4**	**5**
c.	ecclesiastical leaders	**1**	**2**	**3**	**4**	**5**
d.	newsmedia (paper, TV, radio)	**1**	**2**	**3**	**4**	**5**
e.	your employer	**1**	**2**	**3**	**4**	**5**
f.	friends, relatives, neighbors and coworkers	**1**	**2**	**3**	**4**	**5**
g.	yourself and your immediate family	**1**	**2**	**3**	**4**	**5**

6.	Do you have any of the following in the place where you live?	**No**	**Yes**
a.	a working transistor radio with spare batteries	**1**	**2**
b.	at least 4 gallons of water in plastic containers	**1**	**2**
c.	a complete first-aid kit	**1**	**2**
d.	a 4 day supply of dehydrated or canned food for yourself and your family	**1**	**2**
e.	a fire extinguisher	**1**	**2**
f.	wrenches to operate utility shutoff valves and switches	**1**	**2**

7.	Have you done any of the following for the place where you live?	**No**	**Yes**

a.	strapped water heaters, tall furniture, and heavy objects to the building walls	**1**	**2**
b.	installed latches to keep cabinets securely closed	**1**	**2**
c.	developed a household earthquake emergency plan	**1**	**2**
d.	learned where and how to shut off water, gas, and electric utilities	**1**	**2**
e.	learned the location of nearby medical emergency centers	**1**	**2**
f.	purchased earthquake insurance	**1**	**2**
g.	joined a community organization dealing with earthquake emergency preparedness	**1**	**2**

8.		**Not at**				**Very great**
	What degree do you perceive your house will survive a major earthquake	**all** **1**	**2**	**3**	**4**	**extent** **5**

9.	To what extent do you expect your personal safety in an earthquake to be determined by the actions of...	**Not at all**				**Very great extent**
a.	myself and my immediate family?	**1**	**2**	**3**	**4**	**5**
b.	friends, relatives, neighbors or coworkers?	**1**	**2**	**3**	**4**	**5**
c.	local newsmedia?	**1**	**2**	**3**	**4**	**5**
d.	local government agencies?	**1**	**2**	**3**	**4**	**5**
e.	state or federal government agencies?	**1**	**2**	**3**	**4**	**5**
f.	ecclesiastical leaders?	**1**	**2**	**3**	**4**	**5**
g.	luck or chance?	**1**	**2**	**3**	**4**	**5**

10. What type of material is your house built of? _____ wood-frame _____unreinforced masonry _____reinforced masonry _____don't know _____other (please specify)_____

11. How old are you? _____ **years old**

12. What is your sex? _____ **Male** _____ **Female**

13. To which of the following ethnic groups do you belong and identify? _____

Hispanic_____ **Asian/Pacific Islander**_____ **African American** _____

Caucasian_____ **Native American**_____ **Mixed**_____ **Other**

14. What is your marital status? _____ **Married** _____ **Single**
_____ **Divorced** _____ **Widowed**

15. What is your highest level of education? _____ **Less than high school** _____ **High school** ____ **Some college/vocational school**_____ **College graduate**_____ **Graduate school**

16. What is your *yearly* household income? _____ **Less than $15,000**_____ **$15,000–30,000**_____ **$30,000–45,000**_____ **$45,000–60,000**_____ **More than $60,000**

17. Do you own or rent the home where you now live? _____ **Own**_____ **Rent**

18. How many years have you lived in the home where you now live? _____ **years**

19. Are there children living in your household that are...	**No**	**Yes**
a. under the age of 6?	**1**	**2**
b. between 6 and 18 years old?	**1**	**2**

20. Is any of the following statements true about your experience with earthquakes?	**No**	**Yes**
a. Your immediate family's property has been damaged in an earthquake	**1**	**2**
b. You or an immediate family member has been injured in an earthquake	**1**	**2**
c. Property of a friend, relative, neighbor, or coworker you know personally has been damaged in an earthquake	**1**	**2**
d. A friend, relative, neighbor, or coworker you know personally has been injured in an earthquake	**1**	**2**

Do you have any additional comments about earthquake preparedness?

REFERENCES

Abbott, P.L. (2006). *Natural disaster.* New York, McGraw-Hill.

Adeola, F.O. (2000). Endangered commonly, enduring people: Toxic contamination, health, and adaptive responses in a local context. *Environment and Behavior*, *32*, 209-249.

Burton, J. Kates, R.W., & White G.F. (1978). *The Environment as hazard*. New York: Oxford University Press.

CERT (2004). Community Emergency Response Team. Salt Lake County, Retrieved from: http://homeland.slco.org/html/ep_cert.html.

Davis, M.S. (1989). Living along the fault line: An update on earthquake awareness and preparedness in Southern California. *Urban Resources*, *5*, 8-14.

Dooley, D., Catalano, R., Mishra, S., & Serxner, S. (1992). Earthquake preparedness: Predictors in a community survey. *Journal of Applied Social Psychology*, *22*, 451-470.

Edwards, M.L. (1993). Social location and self-protective behavior: Implications for earthquake preparedness. *International Journal of Mass Emergencies and Disasters*, *11*, 293-304.

Farley, J.E., Barlow, H.D., Finkelstein, M.S., & Riley, L. (1993) Earthquake hysteria, before and after: A survey and follow-up on public response to the Browning forecast. *International Journal of Mass Emergencies and Disasters*, *11*, 305-322.

Flynn, J., Slovic, P., & Mertz, C.K. (1994) Gender, race, and perception of environmental health risks. *Risk Analysis*, *14*(6), 1101-1108.

Folger, P. (2010). Earthquakes: Risk, detection, warning, and research. Retrieved from Congressional Research Service Web Site: http://www.fas.org/sgp/crs/misc/RL33861.pdf

Fothergill, A. (1996). Gender, risk, and disaster. I*nternational Journal of Mass Emergencies and Disasters*, *14*, 33-56.

Fothergill, A. & Peek, L. (2004). Poverty and disasters in the United States: A review of recent sociological findings. *Natural Hazards*, *32*, 89-110.

Garcia, E.M. (1989). Earthquake preparedness in California: A survey of Irvine residents. *Urban Resources*, *5*, 15-19.

Jackson, E.L. (1977). Public response to earthquake hazard. *California Geology*, *30*, 278-280.

Jackson, E.L. (1981). Response to earthquake hazard: The West Coast of North America. *Environment and Behavior*, *13*, 387-416.

Kunreuther, H., Ginsberg, R., Miller, L., Sagi, P., Slovic, P., Borkan, B., & Katz, N. (1978). *Disaster insurance protection: Public policy lessons*. New York: Free Press.

Lindell, M.K. & Hwang, S.N. (2008). Households' perceived personal risk and responses in a multihazard environment. *Risk Analysis*, *28*(2), 539-556.

Lindell, M.K. & Prater, C.S. (2000). Household adoption of seismic hazard adjustments: A comparison of residents in two states. *International Journal of Mass Emergencies and Disasters*, *18*(2), 317-338.

Lindell, M.K. & Prater, C.S. (2002). Risk area residents' perceptions and adoption of seismic hazard adjustments. *Journal of Applied Social Psychology*, *32*(11), 2377-2392.

Lindell, M.K. & Perry, R.W., (2000). Household adjustment to earthquake hazard. *Environment and Behavior*, *32*(4), 461-501.

Lindell, M.K. & Whitney, D.J. (2000). Correlates of household seismic hazard adjustment adoption. *Risk Analysis*, *20*(1), 13-25.

Mileti, D. S. (1999). *Disasters by design: A reassessment of natural hazards in the United States*. Washington, DC: Joseph Henry Press.

Mileti, D.S. & Darlington, J.D. (1997). The role of searching in shaping reactions to earthquake risk information. *Social Problems*, *44*, 89-103.

Morrow, B.H. (1999). Identifying and mapping community vulnerability. *Disasters*, *23*(1), 1-18.

Mullis, J-P. & Duval, T.S. (1995). Negative threat appeals and earthquake preparedness: A person-relative-to-event PrE model of coping with threat. *Journal of Applied*

Social Psychology, *25*, 1319-1339.

Perry, R.W. & Lindell, M.K. (2008). Volcanic risk perception and adjustment in a multi-hazard environment. *Journal of Volcanology and Geothermal Research*, *172*, 170-178.

Sjoberg, L. (2000). Factors in risk perception. *Risk Analysis*, *20*(1), 1-11.

Slovic, P. (1987). Perception of Risk. *Science*, 236, 280-285.

Smith, RB. & Sbar, M.L. (1974). Contemporary tectonics of the interior of the western United States with the emphasis of the Intermountain seismic belt. *Geological Society of America Bulletin*, *85*, 1205-1918.

Snuffer, D. (2011). *Passing the heavenly gift*. Salt Lake City, Mill Creek Press.

Utah Department of Public Safety (2011). Division of emergency management. Retrieved from: http://publicsafety.utah.gov/emergencymanagement/.

Utah's Governor's Office of Planning and Budget (2009). Demographics: Population estimates. Retrieved from: http://governor.utah.gov/dea/demographics.html

Utah Seismic Safety Commission (2008). Putting down roots in earthquake country: Your handbook for earthquakes in Utah, 1-33.